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SCHOOL OF GRADUATE STUDIES

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FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

OF

RICHARD ADRIAN JARRELL

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Room 107, 16 Hart House Circle

THE LIFE AND SCIENTIFIC WORK OF THE TÜBINGEN ASTRONOMER MICHAEL MAESTLIN, 1550-1631

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THESIS

THE LIFE AND SCIENTIFIC WORK OF THE TÜBINGEN ASTRONOMER MICHAEL MAESTLIN, 1550-1631

(Summary)

In this thesis an attempt has been made to give the most complete biographical account to date of Michael Maestlin and to analyse his scientific work in the light of his contemporary scholarly milieu. While he was the mentor of the greatest astronomer of the early 17th century, Johannes Kepler, he has never been given a thorough historical consideration. Particular attention has been given to Maestlin's astronomical thought and contributions, especially his role in the Copernican Revolution. The first chapter is purely biographical; it includes information on his background, education, and his teaching career in Heidelberg and Tübingen, as well as a discussion of his family, friends, and colleagues. An assessment of Michael Maestlin the man has also been given.

The second chapter concerns Maestlin's scientific work: his polemic against the Gregorian reform of the calendar is detailed, for he was one of the most formidable opponents of the reform, eliciting a defence from Clavius himself. Since Maestlin was a teacher of mathematics, his wide-ranging mathematical studies (mostly pedagogical) have been examined. In this chapter the author has also discussed Maestlin's popular ephemerides and his works in the field of Biblical chronology.

The third chapter, concerning Maestlin's astronomical work, is the most important. It has been shown that he was a resourceful observer, whose special objects of attention were the sun and moon. His thoughts on solar and lunar astronomy show much innovation and understanding. The author has analysed his works on the nova of 1572 and the comets of 1577, 1580, and 1618. His greatest contribution was in cometary theory, for, by his observations of the comet of 1577, he was the first to assign a specific orbit to a comet. His reflections on the nova and the comets led him to break with many of the Peripatetic notions of celestial physics and cometary theory. His pedagogical works on astronomy are also reviewed, especially his popular Epitome Astronomiae. The final section of the chapter is devoted to his astronomical Weltansicht: his fiath in geometric method in astronomy, his rejection of both physical causation and astrology, his belief in an a priori arrangement of the planetary spheres, and most important, his adherence to Copernicanism. While historians until very recently have maintained that Maestlin held and taught Copernican astronomy only privately, an endeavour has been made to show that, on the contrary, he openly supported and actively promoted the heliocentric theory.

The fourth chapter deals with Maestlin's relations with his students, friends, and contemporaries. His importance to Kepler receives the most attention for it is through Maestlin that Kepler became a Copernican. Also included are several important students such as Schickard, Andreae, and Hafenreffer as well as correspondents like Tycho Brahe, Hagecius, Röslin, and others. Finally, there is a section devoted

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to contemporary and near-contemporary opinions of Maestlin's astronomical work. Appendices include a chronology of the chief events of his life, an annotated bibliography of his printed works, and a technical appendix on the comet of 1577.

The conclusion of the thesis is that Maestlin was far from being the mediocrity and traditionalist as he has been portrayed and that he was an important teacher, excellent observer, rational and independent thinker as well as a promoter of the Copernican theory. The author holds that Maestlin's life and work may typify many other scientific lives of second-rank; further study of similar figures may reveal a richness of thought like that of Maestlin.

BIOGRAPHY

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PUBLICATION

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THE LIFE AND SCIENTIFIC WORK OF THE TÜBINGEN ASTRONOMER MICHAEL MAESTLIN, 1550 - 1631

by

RICHARD A. JARRELL

A Thesis submitted in conformity with
the requirements for the Degree of Doctor of Philosophy
in the University of Toronto

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PREFACE

This work is, to my knowledge, the first extended work on the life and work of Michael Maestlin. Like most first works on a subject, it no doubt suffers from a certain degree of historical astigmatism but will give an indication of the richness of one of the many scientific lives hitherto ignored by historians of science.

While this dissertation was in progress, I learned that Robert Westman of U.C.L.A. had completed a doctoral dissertation on the early thought of Johannes Kepler which contains pertinent information on Maestlin's role in the formation of his student's thought. Since this work was not available at the time, I have not been able to see it; however, I have been concerned with Kepler only as an important student of Maestlin's and have not dealt with his work at length. Westman's thesis may, indeed, be a valuable addition to our knowledge of the influence of Michael Maestlin.

I must first of all acknowledge the Canada Council which gave the financial support necessary for this undertaking. My debt is great to my advisor Professor Stillman Drake who read the manuscript in progress and offered much guidance and many suggestions. I am also indebted to Dr. Henry C. King and Dr. J.W. Abrams for their suggestions and to Dr. C. Doris Hellman who graciously offered information and encouragement; it is her book on the comet of 1577 that led me to this topic originally. Thanks must go to Mrs. Martha List in Munich, Prof. Dr. Reinhold Rau in Tübingen, and Pastor Otto Haug of Schwäbische-Hall

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for important documentary information on Maestlin; and to the librarians at Vienna, Wolfenbüttel, Tübingen, and Stuttgart who not only photographed the manuscripts and printed works I requested but also searched for bibliographical references. Finally, I want to thank my wife Marti who aided me in the typing of the several drafts and helped clarify many stylistic errors.

Toronto, 1971

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LIST OF ABBREVIATIONS

The following abbreviations are for often-used works and libraries from which material originated.

ADB Allgemeine Deutsche Biographie. Leipzig: Duncker and Humblot, 1875-1912.

DSB Dictionary of Scientific Biography. Ed. Charles C. Gillispie. New York: Charles Scribner's Sons, 1970- .

F Joannis Kepleri Astronomi Opera Omnia. Ed. Christian Frisch. Frankfurt: Heyder and Zimmer, 1858-71.

GW Johannes Kepler Gesammelte Werke. Ed. Walther von Dyck and Max Caspar. Munich: C.H. Beck, 1938- .

NE Le Opere di Galileo Galilei Ristampa Della Edizione Nazionale. Ed. Antonio Favaro. Florence: Barbèra Editore, 1929-39.

Tycho, Op. Om. Tychonis Brahe Dani Opera Omnia. Ed. J.L.E. Dreyer. Hauniae: In Libraria Gyldendaliana, 1913-29.

BM British Museum, London

BN Bibliothèque Nationale, Paris

EK Evangelische Kirchenregisteramt, Tübingen

HAB Herzog August Bibliothek, Wolfenbüttel

HS Hauptstaatsarchiv, Stuttgart

NYPL New York Public Library

ÖN Österreichische Nationalbibliothek, Vienna

UT Universitätsbibliothek, Tübingen

UAT Universitätsarchiv, Tübingen

WL Württembergische Landesbibliothek, Stuttgart

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INTRODUCTION

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INTRODUCTION

One would not be far wrong in saying that the history of science has hitherto dealt with the great scientific ideas and the men and women who produced them. The discoveries and theories of the Keplers, Galileos, and Newtons have, naturally, been the object of study in a young discipline; yet, the development of science has not been entirely the province of genius but has always relied upon many lesser thinkers. The latter extend the ideas of genius, filling in the gaps and discovering further applications of the theories. Precisely what rôle they play in science cannot be assessed easily due to the lack of in-depth historical scholarship. This work is an attempt to study one of those scientists--Michael Maestlin.

Maestlin stood on the watershed between ancient and modern astronomy. The world-view held by virtually every educated person at the time of Maestlin's birth was a synthesis of Aristotle and Ptolemy, with medieval and Renaissance contributions; Copernicus had but a handful of followers and Tycho Brahe was as yet a small boy. During Maestlin's lifetime, however, the great works of Tycho, Kepler, and many by Galileo were written, and Newton was born just eleven years after the death of Maestlin. Astronomers were witnessing exciting events in the heavens: the new stars of 1572 and 1604, the great comets of 1577 and 1618, and, after Galileo's telescopic discoveries of 1610 and afterward, a great number of hitherto unsuspected objects. These events played no small rôle in the change of attitude in astronomers' minds, nor was Michael Maestlin immune to the

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effects that these events produced. This work will describe his rôle in this period of change in astronomy and attempt to assign his true place in the astronomical revolution.

In Chapter I, Maestlin's life has been given a somewhat more thorough treatment than has been given before. As one of those many lesser lights in the history of science, he has never received the attention he deserves. Besides the many (generally erroneous) notices in biographical collections, only three biographical articles of any length have been published--those of Karl Steiff, Siegmund Günther, and Viktor Kommerel.[1] The two latter authors drew much of their material from Steiff who, in turn, relied upon the rambling sketch of Maestlin by the nineteenth-century astronomer J. F. C. Bohnenberger.[2] The situation in biographical articles should improve on the publication of Edward Rosen's article.[3] Our knowledge of Maestlin's life is enriched by a short autobiographical tract written in 1609 and preserved in Wolfenbüttel.[4] In addition to the basic information that can be gleaned on his life, I have given a description of the university and its faculty at Tübingen during his student days and during his tenure afterwards.

Maestlin's education and his supposed trip to Italy, during

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[1]Karl Steiff, "Der Tübinger Professor der Mathematik und Astronomie Michael Mästlin," Literarische Beilage des Staats-Anzeigers für Württemberg, (1892), pp. 49-64; 125-128. [Hereinafter cited as Steiff, "Michael Mästlin"]. Siegmund Günther, "Michael Mästlin," ADB XX, pp. 575-580. [Hereinafter cited as Günther, "Mästlin"]. Viktor Kommerel, "Michael Mästlin, Astronom und Mathematiker, 1550-1631," Schwäbische Lebensbilder, 4 (1948), pp. 86-100. [Hereinafter cited as Kommerel, "Mästlin"].

[2]WLB MS Cod. Hist. 2° 657. Undated.

[3]Forthcoming in DSB.

[4]HAB MS Cod. Guelf. 15.3 Aug. 2°.

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which he was said to have converted Galileo to Copernicanism, are considered. I have then described his service with the Lutheran church and his short professorship at Heidelberg before returning to his alma mater. I have also treated his forty-seven year teaching career at Tübingen and his family life. A final section deals with his friends, students, and correspondents and with Maestlin the man.

Of the many intellectual upheavals of the sixteenth century, few have had such far-reaching effects as the struggle over the Gregorian reform of the calendar. Chapter II will detail Maestlin's role in the controversy and examine his works against the reform. A section of this chapter will deal with his ephemerides. The other scientific interests of Maestlin are also dealt with in Chapter II, including his mathematical studies, his work in geography, and his lifelong interest in Biblical chronology. Although none of these interests were as important as astronomy in his life work, they accounted for a considerable amount of his time.

Chapter III deals with the most important aspect of Maestlin's scientific work--astronomy--and discusses his observational, theoretical, and pedagogical work. Particular attention has been paid to his writings on comets; his tract on the comet of 1577 was his most seminal work. In addition, I will outline his views on various astronomical questions such as the rôle of astrology, the use of astronomical hypothesis, mathematics in astronomy, and most importantly, his participation in the advancement of the Copernican theory. His adherence to the ideas of Copernicus has been his chief claim to historical fame, for his teaching led the young Kepler to embrace the Copernican view of the world. Until quite recently, many histories of science, such as those of Berry and Caspar,

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have maintained that Maestlin was a Copernican only in private; Caspar, especially, felt that he feared for his position at Tübingen. I shall show that this view is patently absurd and that he was well-known as a Copernican, publicly defending the heliocentric notions.

In Chapter IV, I have given more detail concerning the friends, students, correspondents, and contemporaries of Maestlin who are mentioned in the first chapter. Primary interest is in Johannes Kepler, for he is the best known of Maestlin's students; however, Maestlin taught a great number of students during fifty years of teaching, some of whom have not been forgotten in the history of science and mathematics. In the concluding section of the last chapter, I have given a number of contemporary and near-contemporary opinions of and allusions to Maestlin's scientific work in order to ascertain his reputation in his own period. Having long been in the shadow of his illustrious pupil Kepler, he must now be evaluated for his own contributions; my conclusions will be an attempt at evaluation.

Appendix material includes a chronology of the chief events of Maestlin's life, an annotated bibliography of his printed works, and a technical appendix to Chapter III dealing with his orbit for the comet of 1577.

The object of the present study has been to give an overall picture of Maestlin's life and achievements and to assess his place in the history of science. This dissertation is, by no means, the final word on Michael Maestlin. I have not attempted an exhaustive study of his life and work, for the amount of manuscript material by him is quite extensive. I hope that further, deeper studies on various aspects of Maestlin's scientific interests will follow this work and, in more gen-

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eral terms, that more attention will be given by historians of science to the many secondary but indispensable figures of science.

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CHAPTER I

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CHAPTER I

THE LIFE OF MICHAEL MAESTLIN

1.0 The Sixteenth Century Background

Although he lived into the first third of the seventeenth century, Michael Maestlin was a child of the sixteenth -- intellectually and spiritually as well as physically. The period preceeding his birth in 1550 was exciting and turbulent in Germany: it was a time of the further weakening of an already tottering empire, the growth of the power of princes, and a period of intellectual ferment and rapid social change. Germany entered the Renaissance later than its southern neighbor, Italy, but with no less turmoil or enthusiasm. The central event of the German-speaking world in the sixteenth century was, of course, the Protestant reformation. Beginning with Martin Luther's audacious break with Rome early in the century, the Protestant revolt spread and evolved with bewildering rapidity, spawning Calvinists, Schwenkfeldianists, Zwinglianists, and innumerable small sects. By the time of Maestlin's birth, a great number of German princes had subscribed to the Evangelical faith with the Confession of Augsburg (1530). While Charles V attempted to halt the religious rebellion by force, the new faith gained converts; the military solution eventually failed, ending with the Peace of Augsburg in 1555. Mid-century marked the beginning of more than sixty years of relative peace between the Catholic emperor and princes on the one hand and the Protestant princes on the other.

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It was in this period of political and religious calm that Maestlin was raised, educated, and accepted into the learned community. The latter half of the sixteenth century was also a period of economic advance in Germany and, particularly in Württemberg, a period of the growth of political power for the middle class.

In the latter half of the century the religious picture was complicated. Luther was dead, and his Evangelical faith was splintering into warring factions. Orthodoxy was maintained in parts of Germany by the Formula of Concord (1580), but many rulers turned to other varieties of Protestantism such as Calvin's Reformed faith. The political picture remained clouded, for the Peace of Augsburg had canonized the principle of cuius regio, eius religio which allowed princes to specify the religious practise of their subjects. More than one principality changed religious allegiance several times in the course of the century. During Maestlin's lifetime, however, his native Württemberg remained stable by maintaining Lutheranism as the state religion.

Scientific works published during the sixteenth century in Germany were numerous: German scientists participated fully in the blossoming of science during the Renaissance.[1] Universities in Vienna, Tübingen, Heidelberg, Basel, Wittenberg, and other German towns produced many scientific writers of note who were not inferior to their Italian, French, or English counterparts. Maestlin's own school, Tübingen, boasted Stöffler, Stadius, and, by the end of the century, the greatest German astronomer of the Renaissance, Johannes Kepler (1571-1630). Tübingen University flourished in this period, due in part to the economic,

---

[1]I use the term "Renaissance" in a wide sense. For Germany, I understand it as the period from roughly 1450 to the Thirty Years' War (1619-48).

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social and political stability of Württemberg.

Württemberg in the sixteenth century was one of the quieter social and political divisions of Germany. Created out of the mediaeval county, Swabia, the Duchy of Württemberg retained its geographical integrity, for constitutionally it could not be divided among the sons of a duke. Within the bounds of Württemberg dwelt small farmers and townsmen whose chief occupation was, by the sixteenth century, viticulture -- particularly in the valley of the Neckar. In all, about fifty cities and towns comprised the duchy, none of them very large. Stuttgart, then as now the capital and chief town, and Tübingen, the intellectual centre, were the two main urban centres of the region. Most of the smaller towns were distinguishable from the farming villages only by differences in forms of government. Several towns in the area which should have been part of the duchy had been granted the privilege of being Imperial Free Cities, Heilbronn and Weil-der-Stadt (Kepler's birthplace) being examples.

The Stuttgart Line, rulers of Württemberg, reigned over the duchy nearly uninterrupted from the time of Count Eberhard VI (ruled 1480-96) until the last king of Württemberg abdicated in 1918. Eberhard himself was named duke by Emperor Maximilian I in 1495. Duke Ulrich VI (1487-1550) ascended the throne in 1498 but was forced out of Württemberg in 1519 by the Hapsburgs. While in exile, the duke embraced the Evangelical faith and, on his return to the duchy in 1534, decided to introduce Lutheranism as the state religion (an early example of the doctrine of cuius regio, eius religio during the Reformation). This he did the following year.[1] It was at this time that the Catholic

---

[1]F.L. Carsten, Princes and Parliaments in Germany (Oxford: Clarendon Press, 1959), p. 19. [Hereinafter cited as Carsten, Princes.]

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monasteries of the duchy were secularized and made schools for Lutheran youth.

By the sixteenth century, serfdom was nearly finished in Württemberg. By the Treaty of Tübingen in 1514, the urban classes had gained some privileges from the dukes, these freedoms continuing to be fought over for many generations. Each duke had to subscribe to the Treaty, and each duke tried his uttermost to circumvent it. The nobility of Württemberg were practically of no local political consequence by then, for they had eagerly sought the status of Freiherrn or Free Imperial Knights. Once granted that privilege, they were, for the most part, content to leave the political development of the duchy to the townsmen, duke, and civil servants. The outstanding political class at this time was the urban Ehrbarkeit: the merchants, artisans, etc. The Swabian Ehrbarkeit were not so well-to-do as their counterparts in the French bourgeoisie or the English middle class,[1] but in the absence of a strong nobility or Catholic hierarchy, they attained a great amount of political influence and prestige. In Württemberg there was much less friction between town and country or between urban middle class and nobility than in other regions; nor were the trades restricted to urban centres as they were in many places in Europe. The fact that towns differed little from the country villages except in administrative structure produced fewer tensions within the duchy.

This relatively quiet and prosperous corner of Germany remained thus until the Thirty Years' War when the duchy was devastated and, in some areas, practically depopulated. During Michael Maestlin's youth, however, Württemberg must have been one of the most pleasant places in

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[1]Carsten, Princes, p. 4.

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which to live.

1.1 Maestlin's Youth, Family, and Education

Michael Maestlin[1] was born in the Swabian village of Göppingen on 30 September 1550[2] at 2.30 in the morning.[3] The son of Jakob Maestlin and Dorothea Simon, he was born into a Protestant family.[4] Since the baptismal records of Göppingen did not begin until 1558,[5] little information can be gleaned concerning Jakob Maestlin's children; however, Maestlin himself tells us in his autobiographical sketch of a sister, Elisabeth, born in 1546 and married at least twice.[6] According to him, she was still alive in 1609 at the age of sixty-two. Maestlin's younger brother, Matthäus, was born in 1559, just after the baptismal

---

[1]Maestlin's name was also spelled Mästlin, Moestlin, Maestlinus, Moestlinus, Möstlin, Möschlin, Möschlinus, Mästle, and various other ways. He himself wrote Maestlin in Latin and Mästlin in German. I have followed the Latin form, for it has been generally employed by historians.

[2]Edmund Reitlinger, Johannes Kepler (Stuttgart: Grüninger, 1868), p. 85, gives 20 September, possibly a confusion of calendar styles. [Hereinafter cited as Reitlinger, Kepler.] W.L.R. Cates, A Dictionary of General Biography (London: Longmans, Green & Co., 1867), p.639 [hereinafter cited as Cates, Dictionary] and Alexander Chalmers, The General Biographical Dictionary (London, 1915), XXI, p. 99 [hereinafter cited as Chalmers, General Dictionary] both give 1542 as Maestlin's birthdate. I have relied upon the dates taken from records by Professor Dr. Reinhold Rau, Lehrbeauftragter at the Universität Tübingen, communicated to me by letter of 23.7.70.

[3]HAB MS Cod. Guelf. 15.3 Aug. 2°.

[4]A.D. White, History of the Warfare of Science with Theology in Christendom (New York: Dover, 1960), I, p. 184, calls Maestlin a "Swabian Protestant". [Hereinafter cited as White, Warfare of Science with Theology.]

[5]Steiff, "Michael Mästlin," p. 50.

[6]HAB MS Cod. Guelf. 15.3 Aug. 2°. Maestlin received a letter from his brother-in-law, Samuel Überman, minister at Weißberg before the former's departure for Heidelberg; this Überman may have been the husband of Maestlin's sister Elisabeth. (Ibid.)

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records began to be maintained in Göppingen.[1] Michael's uncle, Matthäus Maestlin, is mentioned in a letter concerning the family arms sent by Johann Casimir, regent of the Palatinate, and dated 3/13 May 1584.[2] Matthäus Maestlin also had a son named Matthäus, who communicated meteorological observations to his cousin.[3] No other information concerning Jakob Maestlin's family is in the Maestlin manuscripts. Maestlin says of his family that they were pious, unlearned, and, while having normal fortunes, not rich.

That the Bürgermeister stood as Godfather to Matthäus Maestlin, Michael's brother, indicates that the family had some social standing in its community. Little is known of Maestlin's ancestors; some of the following information was collected by Decker.[4] The original family name of the Maestlins was Leckher or Legecker, and the family lived in the village of Boll, a few kilometers south of Göppingen. The records are incomplete, but Decker found one Legecker, a bürger of Boll, who was born about 1400. His son (?) may have been Heinz Leckher, being born in Boll c. 1430 and dying there after 1468. A third Leckher (or perhaps Mästlin) lived in Boll, having been born c. 1460 and having died c. 1500. This was probably Michael's great-grandfather. His son, Jakob Mästlin the Elder, was a bürger of Göppingen; he was born in Boll c. 1490 and died in Göppingen between June 1565 and August 1566. His wife is unknown.

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[1]Steiff, "Michael Mästlin," p. 50. The local bürgermeister acted as Godfather.

[2]In Cod. Guelf. 15.3 Aug. 2°.

[3]Ibid. The letter, dated 30.9.1580, described multiple rainbows and a ring about the moon. The letter is accompanied by crude drawings.

[4]Martin Decker, "Die Ahnen des Astronom Mästlin," Blätter für Württembergische Familienkunde, Bd. 8 (1939), pp. 102-4. [Hereinafter cited as Decker, "Ahnen"].

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His son, Jakob Mästlin the Younger, Michael's father, was born in Göppingen c. 1520 and died sometime between 1566 and 1591, although Steiff gives 1590 as Jakob's death date.[1]

The manner in which the family name of Legecker became Mästlin is related in Maestlin's autobiography. There he claims that his ancestor (presumably either Heinz Leckher or his father) was dubbed "Mästlin," a nickname which might be translated as "fatso," by an old blind woman who touched him and exclaimed: "Wie bist du doch so mast und feist! Du bist ein rechter Mästlin!" As Maestlin relates, the family always tended toward the heavy side, and if the portraits of our astronomer are accurate, the family trait was still alive in its famous scion.

Even less is known of Maestlin's mother. Her maiden name, Dorothea Simon, is given in baptismal records in Göppingen at the time of Matthäus' baptism (29 August 1559).[2] Decker[3] attempted to discover her ancestry, but the evidence is circumstantial. As there were no Simons in Göppingen at the time, Jakob must have found his wife in a village nearby. In Bezgenried, between Boll and Göppingen, a Catholic chaplain named Sigmund Simon (or Sigmundus Simonius) resided until 1538. He was born in Wildbad in the Black Forest c. 1490 and had matriculated at Tübingen[4] in 1508 for the study of theology, later being assigned to Bezgenried. Dorothea may have been born between 1525 and 1530 (as an

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[1]Steiff, "Michael Mästlin," p. 50.

[2]Decker, "Ahnen," p. 102.

[3]Ibid., p. 103.

[4]Heinrich Hermelink et al., Die Matrikeln der Universität Tübingen (Stuttgart: W. Kohlhammer, 1906), I, p. 166. He attained his B.A. in 1510. [Hereinafter cited as Hermelink, Matrikeln.]

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illegitimate daughter) and later was legitimized when Duke Ulrich proclaimed Württemberg Lutheran in 1534; legitimization of the children of priests was evidently commonplace at the time. Decker thinks that Simon's wife (Dorothea's mother) may have come from the region or actually from Boll, being known, perhaps, to the Mästlin family or even related to them. Dorothea Simon married Jakob Mästlin the Younger in 1549. Dorothea bore Jakob two sons, Michael and Matthäus, and probably a daughter, Elisabeth. Decker says that Dorothea died in the summer (probably May) of 1565, for Jakob remarried (a woman named Maria) in the fall of 1565, their first child being born on 20 August 1566. Assuming the time that would have been customary for Jakob to have mourned, Dorothea must have died in May. Since the last child of Dorothea and Jakob was born on 5 May (Elisabeth?), it is possible that Dorothea died either in childbirth or shortly afterwards.

Prior to Maestlin's schooling, no information seems to remain of his childhood: neither he nor his later biographers have mentioned any anecdotes from this period. When Michael was old enough, he was sent to the nearby Klosterschule in Königsbronn.[1] If we assume that Michael was roughly the same age when he entered Königsbronn as was Kepler when the latter entered the Maulbronn Klosterschule, Michael would have been about fifteen years of age (about 1565). Königsbronn belonged to the group of former Catholic monasteries secularized by Duke Christopher for the education of Evangelical youth.[2] These Lutheran cloister schools maintained the educational procedures and discipline that the Catholics had previously: Michael would have followed strict rules, beginning with rising early for prayers and the reading of the

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[1]Günther, "Mästlin," p. 575. [2]In 1556.

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Old Testament. In the afternoon there would have been the New Testament reading. Bible studies were accompanied by language studies (Latin), rhetoric, logic, and the singing of Psalms twice daily.[1] Königsbronn was not as well known as its sister schools, Maulbronn and Bebenhausen, but the education was essentially the same in all of the high schools. Since the students of these schools were generally scholarship students, I conclude that Maestlin's family could not afford his education. He transferred from Königsbronn to the similar school at Herrenalb about 1566 or 1567.[2] It was from Herrenalb that he went to Tübingen to enrol at the university in November of 1568, matriculating on 3 December of that year.[3]

The University of Tübingen[4] was founded in 1477 by Count Eberhard VI of Württemberg. It consisted of four faculties: those of arts, law, medicine, and theology. Although the theologians normally controlled the school, a much better balance of studies was maintained in Tübingen than in most universities at the time. Count Eberhard had set the salaries of the professors so that students might study at Tübingen without paying a fee,[5] although free tuition does not seem to have been maintained for long.[6] The Reformation introduced long-lasting

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[1]Steiff, "Michael Mästlin," p. 50.

[2]Ibid. Steiff had Maestlin at Herrenalb in 1567, although Günther places him at Königsbronn until 1568 (Günther, "Mästlin," p. 575). Steiff is in agreement with the matriculation records.

[3]Hermelink, Matrikeln, I, p. 487. The entry reads: "Michael Mästle Göppingensis."

[4]A concise and colourful account of Tübingen and the university in the sixteenth century may be found in Reitlinger, Kepler, chap. 4.

[5]Ibid., p. 78.

[6]Maestlin, like Kepler, needed a scholarship at Tübingen. In

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strife into the university, particularly between Lutherans and Zwinglians in the faculty. The outcome of this religious struggle for the university resulted when the Lutheran reformer Erhard Schnepf (1495-1558), who was at the university from 1537 to 1538, was named Generalsuperintendent. Under his leadership, the university became a Lutheran institution.[1] Duke Ulrich VI, the successor of Count Eberhard, introduced the Evangelical faith into Württemberg in 1535, making a concession to the pro-Swiss reformers:[2] in 1547, he created the Stift or Lutheran theological school within the university in place of the old Augustinian monastery. With a Lutheran theological college, religious instruction in the university became effectively Evangelical.

Having matriculated at the University of Tübingen in 1568, Maestlin prepared for his examination for the Baccalaureate, which he duly received on 30 March 1569.[3] As Maestlin relates later in the dedication of his work on the comet of 1577, Duke Christopher had given him a scholarship which had enabled him to study not only theology but also mathematics, a subject which had delighted him since his youth.[4] Since Duke Christopher died in 1568, the scholarship must have been awarded before Maestlin's matriculation in the Arts College, i.e. while he was still at Herrenalb. When he entered the Stift, the university was presided over by Jacob Andreae (1528-90), friend of both Luther

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a letter to Maestlin in 1583 offering him the post at Tübingen, the duke mentions, besides a salary, the "due fruits" (student fees).

[1]Reitlinger, Kepler, p. 78.

[2]Carstens, Princes, p. 19.

[3]Hermelink, Matrikeln, I, p. 487n.

[4]Maestlin, Observatio & Demonstratio Cometae Aetherei (Tübingen,1578) dedication, A3v. [Hereinafter cited as Maestlin, Observatio & Demonstratio.].

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and Melanchthon and chief architect of the Swabian Formula of Concord. Alongside Andreae stood Jacob Heerbrand (1521-1600), a dynamic preacher who was destined to replace the former as Chancellor.

Maestlin recorded the names of the faculty members at Tübingen in 1568.[1] This record gives us an idea of what the academy was like at that time. Andreae was the leader of the theology faculty, acting both as Chancellor and Prefect of the Stiftskirche. Heerbrand was Dean of the church and Theodor Schnepf was the pastor. These three men formed the core of the faculty, with Johann Brent as extraordinary professor. The Law and Medicine faculties numbered ten professors altogether, including the physician Jacob Schegk (1511-87)[2] who taught the Organon of Aristotle. In the Arts faculty, Maestlin's teacher of mathematics was Philipp Apian (1531-89), who had replaced Samuel Siderocrates (Samuel Eisenmenger, 1534-85), the noted astrologer. Siderocrates left Tübingen in 1569, and his astronomy lectures were given in the interim by Johann Bloss. Johann Mendlin lectured on logic while Samuel Hailand, who became a close friend of Maestlin, taught ethics. Georg Liebler was the college "physicus"; Georg Hitzler (perhaps related to the pastor who later refused Kepler communion in Graz) was the college orator; and Martin Crusius (Krauss), the renowned Hellenist, taught Greek and Latin.

Johann Scheublin, an extraordinary professor, gave Siderocrates'

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[1] Cod. Guelf. 15.3 Aug. 2°.

[2] Schegk was an Aristotelian natural philosopher of some note. In 1538 he published his Philosophiae naturalis omnes disputationes ac universa tractatio, followed by In Octo physicorum, sive de auditione physica libros Aristotelis, commentaria (Basel, 1546), and In reliquos Naturalium Aristotelis libros commentaria plane philosophica (Basel, 1550); the two latter works were published together at Frankfurt in 1584.

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mathematical lectures before Apian's arrival. Since Maestlin was at the university in 1569, he may have heard lectures from Eloss and Scheublin as well as from Apian. Jacob Bachtler taught Hebrew, being succeeded by Johann Bartembach in 1575. Nicodemus Frischlin was the college poetry and history professor.[1] Georg Burckhardt, later to become Maestlin's father-in-law, Leonhard Engelhardt, Bartholemew Mägerlin, and Erhard Cellius, the Rector, rounded off the Arts faculty.

Although we are told by at least one biographer that Maestlin studied with Georg Joachim Rheticus (1514-76),[2] his teacher was unquestionably Philipp Apian. Philipp was the son of the famous Peter Apian (1495-1552; author of Cosmographia and Astronomicum Caesareum) and had been educated in Neuberg, Regensburg, and Ingolstadt; the father had taught at Ingolstadt.[3] Philipp also had taught at Ingolstadt, a Catholic university, until 1568 when he was discharged for heresy, a direct result of the Council of Trent.[4] The following year found him called to Tübingen,[5] and there, among his pupils, was Michael Maestlin. He remained with the University of Tübingen until 1582, at which time the enforcement of the Formula of Concord led to his second

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[1] See below, section 4.2.

[2] H. Rössler and G. Franz (eds.), Biographisches Wörterbuch zur Deutschen Geschichte (Munich: Oldenbourg, 1953), p. 457.

[3] Siegmund Günther, Peter und Philipp Apian (Prague, 1882), p. 81. [Hereinafter cited as Günther, Apian.]

[4] Ibid., pp. 103-4.

[5] Hermelink, Matrikeln, I, p. 500. The matriculation entry reads: "Clarrissimus dom. D. Philippus Apianus venit pridie Calendas Februarii [31 January 1570]." He had been called earlier (p. 500n.): "Dr. Philipp Apian, who cannot maintain the position of professor at the school in Ingolstadt on account of pure doctrine, was accepted by the Senate of the School as professor of astronomy and geometry in 1569." Apian was Dean of the Arts Faculty in 1572 and 1578.

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discharge. Since he was considered a crypto-Calvinist by Tübingen authorities (although he seems not to have been[1]), he had to relinquish his position; nevertheless, he remained in Tübingen as a private citizen until his death seven years later.

Günther has given a list of lecture topics belonging to Apian[2] which is of great importance, for, although it is not certain which courses or lectures were offered during Maestlin's residence in Tübingen, the list does give an idea of what topics were being discussed. In mathematics, Apian taught Gemma Frisius' Arithmetic (1540), Euclid's Elements, practical geometry (surveying), and the use of geodetic instruments. He was an accomplished cartographer and had made a survey of Bavaria and constructed a map for Duke Albrecht V in 1554.[3] In astronomy, he relied upon Proclus' Sphaera, the Theoricae Novae Planetarum of Georg Peurbach (1423-61), Winshemius' Sphaera,[4] and his father's Cosmographia. He had a definite mechanical bent and offered instruction in the making of sundials, the use of Peter Apian's quadrant, mapmaking, and the use of globes.

As Maestlin later wrote on sundials[5] and is said to have constructed celestial globes[6] and a map,[7] it would seem that Apian passed on some practical knowledge to his pupil as well as the more academic

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[1]Günther, Apian, p. 104.

[2]Ibid., pp. 108ff.

[3]Baierische Land-Tafeln XXIII (Munich, 1566, and Ingolstadt, 1568).

[4]See below, section 3.3.

[5]See below, section 3.1.

[6]See below, section 3.1.

[7]See below, section 2.4.

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subjects. If he actually included these practical aspects of mathematics and astronomy in his public lectures at Tübingen, it would have represented quite an innovation in the formal, book-oriented university curriculum.

Since Maestlin had his master's degree conferred at Tübingen on 1 August 1571,[1] he would have been able to have studied with Apian for nearly two years. Günther suggests that Maestlin may have drawn a little of his later knowledge from Apian.[2] From the indirect evidence concerning Apian's lectures and the breadth and depth of Maestlin's astronomical and mathematical knowledge, I think that Maestlin owed rather a large debt to his teacher.

Studies at the Stift were directed to produce men for the church service, so Maestlin, after receiving his M.A., was employed as a Repetent or tutor in the Stift from 1571.[3] Many years later, when Maestlin wrote to the Rector and Senate at Tübingen requesting a letter of testimony,[4] the university responded in glowing terms, acknowledging the fact that Maestlin had graduated summa cum laude.[5] Maestlin had ranked third in his graduating class of twenty.[6]

The year following Maestlin's appointment as a tutor brought

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[1]Hermelink, Matrikeln, I, p. 487n.

[2]Günther, Apian, p. 114n.

[3]Steiff, "Michael Mästlin," p. 50. Hermelink, Matrikeln, I, p. 487n., mentions no dates for his tutorship.

[4]Letter of 8 January 1581. Copies are in Tübingen (UAT 15/5 Nr. 4b.) and Wolfenbüttel (Cod. Guelf. 15.3 Aug. 2°).

[5]Letter of 16 January 1581, in Cod. Guelf. 15.3 Aug. 2°.

[6]Gustav Keppler, Keppler Familiengeschichte (Görlitz: Starke, 1930), II, p. 79. [Hereinafter cited as Keppler, Familiengeschichte.]. (Kepler, several years later, was to rank second in his class.)

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the first great astronomical event which was to help shape his reputation -- the New Star of 1572. Perhaps it was due to his observations that Maestlin was given the position of repetent mathematicus the following year.[1]

At this point in Maestlin's career, biographers have almost unanimously placed him in Italy, saying that Galileo Galilei (1564-1642) learned from him the essence of the Copernican system of the world. I will examine in some detail this supposed episode since it has appeared intermittently and has raised questions concerning Galileo's adoption of Copernicanism. The majority of early biographical works that mention Maestlin repeat the story that once the young German had graduated from Tübingen, he journeyed to Italy where he lectured "in a Lyceum" on Copernicus. Galileo, attending the lectures, was convinced by Maestlin and thus became a Copernican.[2] The story seems to appear first in Vossius' account of Maestlin;[3] by the nineteenth century, Hoefer had no doubts: " . . . il se rendit en Italie, où il prononça en faveur du

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[1]Hermelink, Matrikeln, I, p. 487n. Date supplied in Steiff, "Michael Mästlin," p. 51.

[2]A sampling of such notices includes Cates' and Chalmers' dictionaries, J.H. Zedler's Grosses Vollständiges Universal-Lexikon (Leipzig and Halle, 1739) [hereinafter cited as Zedler, Universal-Lexikon], and Ch. G. Jöcher's Allgemeinen Gelehrten-Lexikon (Hildesheim: Georg Olm, 1961) [hereinafter cited as Jöcher, Gelehrten-Lexikon.]. Histories of science which include the story are: E.F. Apelt, Johann Keppler's Astronomische Weltansicht (Leipzig: Weigel, 1849), p. 7, giving Vossius as his source. Reitlinger, Kepler, p. 85n., J.H. von Mädler, Geschichte der Himmelskunde (Braunschweig: Westerman, 1873), I, pp. 210 and 251, and J.L.C. von Breitschwert, Johann Kepler's Leben und Wirken (Stuttgart: Löflund, 1831), p. 18, also give the story.

[3]Gerard Vossius, De universae mathesios natura & constitutione liber (Amsterdam: Joannis Blaeu, 1650), p. 192. Vossius' statement is as follows: Iunior in Italia egit; ubi cùm pro Copernicana sententiâ publicè in Lyceo orationem habuisset; Galileus Galilaeius, perpensis ejus argumentis, etsi antea Aristoteli, & Ptolemaeo, penitùs addictus, postea pedibus, sive animo potiùs, in ejus ivit sententiam.

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système de Kopernik un discours qui décida Galilée à abandonner définitivement le système de Ptolemée."[1] The story finally evolved to the point, in a recently-published biographical dictionary, at which Maestlin and Galileo were associates.[2]

The dates given for the supposed trip fall between 1571 and 1576, when Maestlin was called to Backnang for a position in the church. Wolf and Hellman[3] suspect the journey never took place, and Wohlwill[4] concurs. Steiff and Favaro[5] flatly deny the story. In favour of Maestlin's supposed trip and lecture, there is only Vossius' anecdote. The story may have arisen by confusion from an allusion in Galileo's Dialogue to a lecture on the Copernican theory by a foreigner. In the Dialogue, Galileo has Sagredo say:

> This is the time for me to tell you a few of the things that happened to me when I first began to hear these opinions spoken of. I was then a youth who had scarcely finished the course in philosophy, giving this up in order to apply myself to other activities. It happened that a certain foreigner from Rostock, whose name I believe was Christian Wursteisen, a supporter of the Copernican opinion, arrived in these parts and gave two or three lectures in an academy on this subject. He had a throng of hearers, more from the novelty of the subject than for any other reason, I think. I did not attend them, having formed a definite impression

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[1]Ferdinand Hoefer, Nouvelle Biographie Générale (Paris: Firmin Didot Frères, 1853-70), XXXII, p. 649. [Hereinafter cited as Hoefer, Biographie.]

[2]Allen Debus (ed.), World Who's Who in Science (Chicago: Marquis--Who's Who, 1968), p. 1126; article "Mastlin" (sic).

[3]Rudolf Wolf, Geschichte der Astronomie (Munich: Oldenbourg, 1877), p. 249; C.D. Hellman, The Comet of 1577 and its Place in the History of Astronomy (New York: Columbia University Press, 1944), pp. 140-1. [Hereinafter cited as Hellman, Comet of 1577.]

[4]Emil Wohlwill, Galilei und sein Kampf für die Copernicanische Lehre (Hamburg: Leopold Voss, 1909-26), I, p. 190. [Hereinafter cited as Wohlwill, Galilei und sein Kampf.]

[5]Steiff, "Michael Mästlin," p. 57, and Antonio Favaro, Galileo Galilei e lo Studio di Padova (Padua: Antenore, 1966), I, p. 115.

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> that this opinion could be nothing but solemn foolery. Later, asking about it from some who had gone, I heard them all making a joke of it except one, who told me that the matter was not entirely ridiculous. Since I considered this person an intelligent man and rather conservative, I was sorry that I had not gone; and from then on, as I happened from time to time to meet anyone who held the Copernican opinion, I asked him whether he had always believed in it . . .[1]

The passage has certain superficial similarities to the Vossius' statement about Maestlin; it is also the only passage in which Galileo mentions a possible introduction to the Copernican theory. In the passage, however, it is not Salviati, Galileo's spokesman, who tells the story but rather Sagredo.[2] If the story alludes to an incident in the life of the real Giovanni Francesco Sagredo (1571-1620), the lecture would have taken place after Sagredo's departure from university, presumably in the 1590's. This would have been too late for Maestlin to have been in Italy. If Galileo's passage is autobiographical, the story still would not fit Maestlin, as Galileo left Pisa in 1585 when Maestlin was unquestionably in Tübingen; nor do any of the biographies give a date later than 1576 for the alleged journey.

Even the anecdote of Sagredo leaves problems. Christian Wursteisen (1544-88) was a Basel (not Rostock) scholar whose astronomical works seem to comprise only a commentary on Peurbach,[3] not Copernicus; furthermore, I have seen no evidence to show that Wursteisen was even in Italy. Another Wursteisen, one from Rostock, is more likely to have

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[1]Galileo Galilei, Dialogue Concerning the Two Chief World Systems. Trans. Stillman Drake (Berkeley: University of California Press, 1967), p. 128. [Hereinafter cited as Galileo, Dialogue.]

[2]As Drake points out in: Galileo, Dialogue, p. 478n.

[3]Given by Dreyer in Tycho, Op. Om., IV, p. 506, as Quaestiones novae in Theoricas novas Planetarum Georgii Purbachii (Basel, 1573, and later editions).

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been meant by Galileo, rather than Maestlin, who was certainly not from Rostock.[1] Whether the passage in the Dialogue is autobiographical or not is a moot point, but Galileo did not defend Copernicus until early in 1597, and, in a letter to Kepler of 4 August 1597, he says that he had been a Copernican "for many years".[2]

The dates in question led Wolf, Wohlwill, Steiff and Hellman to doubt that the alleged trip to Italy took place. Between 1571 and 1576 Galileo was between seven and twelve years of age, and he did not finish his course in philosophy until several years later.

That the purported influence occurred after 1576 is another possibility, though a highly unlikely one, for nowhere in his writings or correspondence does Maestlin mention ever having been in Italy. Maestlin's university career is only moderately well documented, but there are no suggestions in the few official documents concerning him that he ever left Tübingen or Heidelberg for the south. It is certain that Maestlin was at Tübingen from 1571 to 1573 as a tutor, at Eßlingen in 1572 when that university withdrew due to the plague, and back in Tübingen the same year; he was also there in 1575 when he substituted for Apian. Finally, in a manuscript preserved in Vienna, there is a book of astronomical observations made by Maestlin from 1572 to 1596 and compiled by Wilhelm Schickard (1592-1635);[3] the manuscript indicates that he resided continuously in Germany throughout the period in question.

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[1]Stillman Drake has mentioned in private conversation that one Urstisius or Wursteisen was a tutor in astronomy in Bologna about the same time. He may have been from Rostock and may have lectured at Padua or Pisa. If Galileo meant this man, his memory must have slipped after many years.

[2]GW XIII, No. 73, pp. 130-1; NE X, No. 57, pp. 67-8.

[3]Cod. Vindob. 10887, fol. 1r-90r.

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His first observations were made in Eßlingen on 27 January 1572, and by 10 May he had returned to Tübingen. There follow observations from 1572 to 7 October 1576. The next record is of an observation on 14 January 1577 in Backnang, where observations continued until 12 December 1580, at which time he left for Heidelberg. With no firm evidence of his having visited Italy, let alone of his having lectured on Copernicus there, I conclude that Vossius was simply misinformed and that others have perpetuated his error.

The first entry of Maestlin's name in the Senate Acts of Tübingen was made in 1575.[1] Philipp Apian had departed for Bavaria, and the Senate asked Maestlin, a mathematics tutor, to stand in for Apian as mathematics professor. During October 1576, Apian was again away. Maestlin was requested once more to substitute for his teacher, but Heerbrand reported that Maestlin had ein condicion and was away himself.[2]

Soon after Maestlin's departure from Tübingen, he dedicated his Ephemerides Novae (1580) to the university, a gesture rewarded by a gift of 20 thalers. In connection with this dedication, Heerbrand said that Maestlin was a fine young man and that there was none equal to him at that studium, to which Schnepf added that he was an ingenium laudabile; Matthias Hafenreffer (1561-1619) referred to excolendum illud egregium ingenium.[3] These statements of esteem must have been gratifying for the young man of thirty.

1.2 In the Church Service and Professor at Heidelberg

Maestlin did not stand in for Apian the second time, for

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[1]Steiff, "Michael Mästlin," p. 50.

[2]Ibid.

[3]Ibid., p. 51.

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Duke Ludwig III had other duties planned for him. Since he had been educated in the Stift at ducal expense, it was decided that he should enter the church service. Maestlin was named deacon at the church in Backnang, a village some 20 kilometers northeast of Stuttgart. He took up his new duties on either 10 November 1576 or in early January 1577,[1] although he may have served for a short time with the church in nearby Winnenden, possibly as a vicar.[2] Steiff gives the date of 24 October 1576 for the decree of Duke Ludwig III's giving Maestlin the post,[3] but I have not seen any documentation concerning the appointment. As mentioned above, Maestlin's last observation at Tübingen was 7 October 1576 and his first in Backnang on 14 January 1577.[4] This dating does not preclude his having held the position in Winnenden simultaneously, as the towns are little more than five kilometers apart. That his wife came from Winnenden supports such a contention.

The church at Backnang evidently did not hold a high opinion of Maestlin. Kommerell relates that the church council said of him: "ohngesehen bei ihm ein defectus und Mangel an Red sich befindit."[5] Although he may not have been the proper sort of speaker for the church, he certainly seemed to have no trouble teaching in universities. The

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[1]Private communication from O. Haug of 4.8.1970. Jöcher, Gelehrten-Lexikon, III, p. 580, gives 1570 as the year and pastor as the post. Zedler, Universel-Lexikon, XXI, p. 810, repeats Jöcher's information. The November date is more likely the correct one, as Maestlin himself gives that month in Cod. Guelf. 15.3 Aug. 2°.

[2]This is Haug's suggestion. In a communication from the EK of 23.7.1970, it is also suggested that Maestlin served in Winnenden.

[3]Steiff, "Michael Mästlin," p. 52.

[4]Although the manuscript gives "1557", an error of the scribe's pen.

[5]Viktor Kommerell, "Mästlin," p. 88.

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Backnang church elders probably looked on Maestlin's unabated astronomical activity with disfavour.

In Backnang Maestlin observed the comet of 1577, an event which helped secure for him a firm place in contemporary astronomy. His treatise on the comet was dedicated to Duke Ludwig of Württemberg, and the latter showed his appreciation by a gift of twenty gulden.[1] Duke Ludwig himself had scientific interests and on several occasions included mention of scientific questions, particularly concerning comets, in his letters to Maestlin. Maestlin reciprocated with observations and opinions. Both his works on the comets of 1577 and 1580 were dedicated to Duke Ludwig; indeed, during the duke's reign, Maestlin seems to have been his chief scientific advisor.

In 1579, Maestlin was writing his Ephemerides Novae and was attempting to obtain an Imperial licence for the work and its successors. With the aid of Hieronymous Wolf in Augsburg and others, he did receive the licence. He also wrote to the ducal secretary, Melchior Jäger, to ensure the duke's privilege would be granted to the new work.

During his stay in Backnang, Maestlin's reputation as an astronomer spread beyond the confined limits of the Tübingen academic community. Tycho Brahe (1546-1601) had read of Maestlin's tract on the nova of 1572 and was well disposed toward the younger man; he was later to reprint the tract in his Progymnasmata of 1602. The Palatine Count, or Pfalzgraf Ludwig VI (1539-83), a patron of mathematics and science, also heard of Maestlin and invited the young deacon to fill the vacant chair of mathematics at the University of Heidelberg.

Maestlin's predecessor at Heidelberg was Simon Grynaeus who was

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[1]Letter of 12 December 1578; Cod. Guelf. 15.3 Aug. 2°.

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removed in the Lutheran purge of the University.[1] The negotiations took some time, for Maestlin had to secure permission from his duke to leave not only his post at Backnang but also the duchy. Some light is shed on the proceedings by the contents of a letter from Duke Karl of Bavaria, Count of Veldentia and Sponheim, and Rector at Heidelberg, which was sent to Maestlin on 13 October 1580.[2] In this letter, the Rector offered Maestlin the position of Professor of Mathematics in Ordinary with a salary of 160 florins per annum and a bonus of 20 florins to help defray the expense of moving his family to Heidelberg. Writing to Duke Ludwig on 28 November 1580, Maestlin[3] notified his lord that the Pfalzgraf desired him to be the new professor at Heidelberg. He noted that the Heidelberg Senate had appointed him professor on 21 November, and made it clear to Duke Ludwig that he would remain a loyal subject, begging permission to leave the duchy if the duke had no further need of his services. Although his request was standard procedure, the situation was somewhat complicated by the fact that he was a member of the church service, which in Württemberg was strictly Lutheran, and he was asking to teach in a principality which had only recently been Calvinist. Heidelberg had become a stronghold of a form of Calvinism on the accession of Pfalzgraf Friedrich III in 1559. Pfalzgraf Friedrich had as his court physician at Heidelberg the influential Thomas Erastus (1524-83), and

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[1]This was not Simon Grynaeus the humanist and reformer, but the medical doctor. Grynaeus wrote two treatises in 1579 addressed to Count Ludwig VI on the nature and signification of comets and ignited meteors. These were printed in 1580 along with treatises by Thomas Erastus, Andreas Dudith, and Marcellus Squarcialupus under the title De Cometis Dissertationes Novae. See Lynn Thorndike, A History of Magic and Experimental Science (New York: Columbia University Press, 1923-58), VI, pp. 91ff. [Hereinafter cited as Thorndike, History of Magic.]

[2]Cod. Guelf. 15.3 Aug. 2°.

[3]HSA MS A63 Büschel 57.

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the count invited a number of Reformed professors to his university. Count Ludwig had restored the Lutherans to favour on his father's death in 1576, but the Calvinist influences remained strong. Eventually, the principality reverted to Calvinism. Duke Ludwig was hesitant to allow Maestlin permission to leave for Heidelberg. As Maestlin had reminded him,[1] however, the new Pfalzgraf was his brother-in-law, a fact which may have facilitated Maestlin's transfer. Permission was finally granted on the condition that he return to his duke's service when the necessity arose.

An expense account submitted by Maestlin to the Heidelberg rector concerning moving his family to Heidelberg survives in Wolfenbüttel.[2] Maestlin went to Heidelberg alone on 16 November 1580 and returned home on the 18th. Later, he moved his family (although both his young daughters were ill) by wagon and boat (down the Neckar) on 19 December, arriving at his new home on 23 December. His costs for the two trips amounted to more than 45 florins, which the rector paid, although Duke Karl had allotted him only 20 florins toward expenses.

The Heidelberg matriculation records have two entries for Maestlin, one in 1580 and the other in 1584.[3] The new mathematics professor signed the register on 31 December 1580 and began teaching in the new year. He did not disappoint his employers, for his teaching is said to have been a great success.[4]

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[1]HSA MS A63 Büschel 57.

[2]Cod. Guelf. 15.3 Aug. 2°.

[3]Private communication from W. Werner, Universitätsbibliothek Heidelberg, 1.7.1970.

[4]See Günther, "Mästlin," p. 575.

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During his stay at Heidelberg Maestlin published several books including his work on the comet of 1580, a dissertation on the fundamental principles of astronomy, and the first edition of his textbook, the Epitome Astronomiae. When the emperor, Rudolf II, requested the Pfalzgraf's opinion of Gregory XIII's calendar reform, Maestlin wrote an opinion for his patron, the Außführlicher Bericht of 1583.

Information concerning Maestlin's stay at Heidelberg is scanty; besides the matriculation records, there are but two entries in the Urkundenbuch of the university but no other archival records.[1] Both entries in the Urkundenbuch are dated 1583: the first is on 6 August.[2] The duke of Württemberg had written the Pfalzgraf reminding him that Maestlin was in Heidelberg only on the condition that the duke did not need his services, which he now wished to have. Telling his brother-in-law that Apian was being discharged for his refusal to sign the Formula of Concord, the duke wished Maestlin to replace him.

The second entry, dated 23 August 1583, is the report from the university to the Pfalzgraf regarding Maestlin's case;[3] it stated that, although Maestlin would gladly remain in Heidelberg, he must obey his duke's orders. The university suggested that perhaps the Pfalzgraf could intercede on Maestlin's behalf. The intercession must have prevailed, for Maestlin's second entry in the Heidelberg Matrikel did not appear until 1584.

Events in Württemberg during Maestlin's absence were to have a

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[1]Private communication from Dr. Weisart, Universitätsarchiv Heidelberg, 7.7.1970.

[2]Urkundenbuch der Universität Heidelberg, Bd. II, p. 145. Entry Ann. XII, 68v., 1255.

[3]Ibid., 69. 1256.

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lifelong influence on his career, for Chancellor Andreae had been at work at the Stuttgart palace preparing the Formula of Concord. With the sanction of both the civil service and the Tübingen professors, Andreae drew up what was to be the definitive statement of Lutheran orthodoxy. The Formula was enacted in 1580, and the signatures of all professors were required for continued teaching at Tübingen. Once again, Apian was caught in the centre of a religious storm; he could not sign the articles. Consequently, Apian was granted a "leave of absence," permanent this time. This vacancy, created by order of the duke, had to be filled. He wrote to the Rector of Tübingen on 13 May 1584 (O.S.) stating that Maestlin was to replace Apian in the chair of mathematics,[1] and the university complied.[2] Duke Ludwig had a better use for him at the university than in a village deaconry.

Maestlin made his last observation in Heidelberg on 29 April 1584 and returned to Tübingen later in the spring. He does not seem to have had any further connections with the church service at Tübingen, although it has been claimed he was a professor of theology.[3] Signing the Formula of Concord would have been no problem for the devout Maestlin, and he soon directed himself to his new duties. Before turning to his years at Tübingen, I wish to discuss his family.

1.3 Maestlin's Family

Within months of arriving in Backnang, Maestlin married Margarete Grüninger, the marriage being celebrated on 9 April 1577 in

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[1]MS UAT 15/5 Nr. 3b.

[2]"23 Mai a senatu scholae nostrae ad docenda mathemata publice conductus." Hermelink, Matrikeln, I, p. 624n.

[3]Private communication, EK, 23.7.1970.

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the nearby village of Winnenden.[1] Born on 21 February 1551 in that village, Margarete was the daughter of the bürgermeister Erasmus Grüninger (1523-1613) and Elisabeta Grüninger, née Fastnach (1524-1611), from Strümpfelbach. Grüninger was later to become a counsellor at the Palace in Stuttgart; he seems to have been well-disposed toward his learned son-in-law. Michael and Margarete Maestlin's first child, Margareta,[2] was born in Winnenden on 24 January 1578. Her birthplace suggests that although Maestlin's post was in Backnang, he and his wife resided in Winnenden. Their first daughter lived to marry Tobias Albert, M.A., a deacon at Dellingen, on 7 December 1602 (O.S.), but she died on 20 September of the following year.

The information on the other Maestlin children from Michael's first marriage is scant. A second daughter, Anna Maria, was born probably in 1579, perhaps in Winnenden or Backnang, and married on 5 June 1604 (O.S.) in Vaihingen; Anna outlived her father. Maestlin's first son, Ludwig, was probably born in Heidelberg in 1581 or 1582 and married on 13 February 1600 (O.S.). His wife's name is unknown to me. In his 1609 autobiographical sketch, Maestlin says that Ludwig became a doctor, and, although he considered him successful, he did not know his whereabouts. Where and when he died is not recorded in Tübingen. A second son, Michael, was born on 5 August 1586 (O.S.), probably in Tübingen. The actions of the younger Michael discomfited Maestlin through the years, for Michael fled from home about 1600 and stayed with,

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[1]Most of the information on Maestlin's family was supplied from the Tübingen records by Dr. Reinhold Rau, Lehrbeauftragter of the University of Tübingen, via private communication from the EK of 23.7.1970. Further information was supplied by O. Haug.

[2]The name is spelled "Margareta" in the Tübingen records, but "Margarete" may have been meant. The spelling of names was very inconsistent.

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or perhaps even joined, the Jesuits. Maestlin relates part of the story to Kepler in a letter of 19/29 October 1600. He was heartbroken for, although he had always tried to teach his son correct behaviour, he had got into petty trouble throughout his youth and now, at the age of fourteen, had committed some humiliating offense and had fled.[1] Maestlin does not elaborate upon the transgression. The flight of the younger Michael had thrown him into depression or melancholy, and the rumour then circulated that he had committed suicide. Herwart von Hohenburg (1553-1622), writing to Kepler in November 1602, mentioned that "he . . . fell into a melancholy. Also, after that he is said to have thus ended his life."[2] Kepler had already heard the rumour but relayed some new information to Herwart on 12 January 1603 (N.S.): "One of my relatives in Tübingen wrote to me and made mention of Maestlin . . . it is certainly true he fell into a melancholy on account of his son, who, they say, is hiding somewhere among the Jesuits."[3] No further mention is made of the younger Michael's troubles. In the 1609 autobiography, Maestlin says that Michael is a painter but has no idea where his son is, so he either had heard news of him or was reconciled with him.

Michael and Margarete Maestlin had two other children, about whom almost nothing is known. A daughter, Dorothea Ursula, was born on 26 July 1584 (O.S.) in Tübingen, and a son, Johann Georg, was born on 2 February 1588 (O.S.), also in Tübingen. Dorothea probably died at birth or soon afterwards as a later daughter was also named Dorothea.

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[1] GW XIV, No. 178, p. 157.

[2] GW XIV, No. 236, p. 313:8-10.

[3] GW XIV, No. 242, p. 354:471-475.

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Johann Georg may also have died soon after birth as there is no later mention of him. On 18 February, barely more than two weeks after the birth of Johann Georg, Margarete Maestlin died at the age of 37. Her death may have been due to complications resulting from Johann Georg's birth. Her untimely death left Maestlin with at least four children for whom to care, a situation which may have influenced his decision to remarry in the following year. On 14 January 1589 (O.S.), he married Margarete Burkhardt, daughter of Georg Burkhardt, a professor of philosophy at Tübingen, and Anna Krebel.

Margarete Burkhardt bore Maestlin eight children. The first, Sabina, was born on 18 January 1590 (O.S.) but lived for only six years, dying on 9 July 1596 (O.S.). Having previously lost his daughter Dorothea, Maestlin named his second child by Margarete Burkhardt Dorothea (born on 23 April 1591, O.S.). No other record of her remains, and I assume she died at or soon after birth, for their third child was named Anna Dorothea. Anna Dorothea was born on 8 July 1593 (O.S.) in Tübingen and lived to marry Andreas Osiander, deacon at Balingen, a namesake and descendant of the famed Lutheran theologian Andreas Osiander who was responsible for the anonymous preface to Copernicus' De Revolutionibus. The marriage took place on the fourth Sunday of Epiphany 1614. Where and when she died I do not know.

The first son of Maestlin and Margarete Burkhardt, Gottfried, was born 12 October 1595 (O.S.). Gottfried married Annamaria Klett on 11 September 1621 (O.S.) and died in 1635, possibly from the plague that then ravaged Württemberg. Another son, August, was born 15 January 1598 (O.S.) but died the following month of epilepsy. A daughter, born 13 June 1599 (O.S.), was named Sabina after the Maestlins' first daughter

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who had died three years earlier. The second Sabina married Burkhard Rümelin, an assessor in the High Court of Tübingen, on 9 August 1624 (O.S.) and lived to an old age, dying on 2 August 1669 (O.S.) in Tübingen. Their last son, Matthäus, named for Maestlin's brother, was born on 10 May 1601 (O.S.); he later married Agnes Unfried, daughter of the Vaihingen bürgermeister Samuel Unfried. Matthäus' wife died in 1661, but when he died I cannot discover. Maestlin's last child by Margarete Burkhardt, Margarete, was born on 16 December 1604 (O.S.), but no record remains of her.[1]

Both Gottfried and Matthäus attended the university at Tübingen. Gottfried received his M.A. in 1615 and was later Professor of Latin at the university.[2] Matthäus took his M.A. in 1622 and became a court clerk in Knittlingen.[3] Gottfried had some interest in astronomy and occasionally aided his father in observing.

Of those children who survived to marry, all seemed to marry into the same social stratum of their father, their husbands and wives coming from the church service or the prosperous Ehrbarkeit. Maestlin outlived not only many of his children but also both his wives. Margarete Burkhardt died on 18 February 1622 (O.S.) in her fifty-eighth year, although she was fourteen years her husband's junior. Maestlin did not remarry after her death. When Maestlin died in 1631, no more than seven of his fourteen children survived.

Maestlin was devoted to his family, and the death of an infant child greatly moved him. In a letter to Kepler 2/12 May 1598, he

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[1]She was named for the earlier Margareta, who died the year before.

[2]Steiff, "Michael Mästlin," p. 53.

[3]Ibid.

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described the death of his month-old son, August.[1] He tells Kepler that the boy was born 15 January but went into an epileptic seizure on the night of 15 February; the seizure lasted until the evening of the 17th, when he died:

> Ah, where is my hope in that? My joy? the rejoicing in that? All is undone in melancholy, tears, and insurmountable sadness. . . The Lord giveth and the Lord taketh away, blessed be the name of the Lord (ah, how painfully this breaks forth from the troubled heart).[2]

He then says he must throw down his pen and write no more.

1.4 Professor at Tübingen

Maestlin signed the matriculation book at Tübingen for the second time on 16 May 1584 (O.S.)[3] and was named Professor of Mathematics on 6 July.[4] He was awarded a salary of 160 florins or thalers per annum besides the "due fruits," or student fees.[5] Upon his return to his alma mater, he found that the personnel of the university had altered somewhat: in 1584 Andreae was still Chancellor and Heerbrand, Schnepf, and Brent were yet in the theological faculty. Stephan Gerlach, an unceasing opponent of Calvinism, had become extraordinary professor in the faculty (and subsequently one of Kepler's professors), as had Johann Vesenbeck, formerly pastor in Maestlin's hometown of Göppingen. Within a few years

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[1] GW XIII, No. 97, pp. 208-9.

[2] Ibid., p. 209:29-31.

[3] "M. Michael Maeschtlinus Göppingensis nomen repetiit." Hermelink, Matrikeln, I, p. 624n.

[4] Steiff, "Michael Mästlin," p. 52. Max Caspar says in 1583: Kepler 1571-1630, translated and edited by C. D. Hellman (New York: Collier Books, 1962), p. 48. [Hereinafter cited as Caspar, Kepler]; Dreyer, in Tycho, Op. Om. IV, p. 504, says 1580.

[5] This compares with the salary of 180 florins given to Galileo when he joined the faculty at Padua. Maestlin's salary was not overgenerous, yet he never complained about finances and seems to have been

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of Maestlin's return, Andreae died (1590) and was replaced by Brent. This was followed by Schnepf's death which allowed Gerlach to move up. Heerbrand was elected the new Chancellor.

In the Arts Faculty Liebler, Hitzler, Hailand, Crusius and Burckhardt remained, but Apian was now replaced by Maestlin. Bartembach was replaced by Georg Waigenmaier as Hebrew professor, while the former Rector Cellius became poetry and history professor due to the misfortunes of the stormy Frischlin. Most of these faculty members were still in residence when Kepler entered Tübingen in 1589, with several additions such as Matthias Hafenreffer, Johann Sigwart, and Andreas Osiander[1] in theology; Osiander eventually became Chancellor after Heerbrand's death in 1600.

Maestlin was soon at home in the academic environment. The esteem of his colleagues soon made itself felt, for he was elected Dean of the Arts Faculty for 1588-89 and was re-elected to the position for terms in 1594-95, 1600-01, 1607-09, 1610-11, 1615, 1623, and 1629 -- two years before his death.[2] Maestlin was liked and respected not only by his colleagues but also by his many students, especially the young Kepler, who arrived during his first term as Dean. Maestlin became an integral member of the close academic-social community of Tübingen.[3]

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well off. He may have supplemented his income, like Galileo, by private tutoring. His books would have brought in small sums as well.

[1]Osiander was the grandson of the reformer; Maestlin's son-in-law may have been the son of this Andreas.

[2]Hermelink, Matrikeln, I, p. 624n.

[3]An important aspect of the collegiate life in Tübingen at the time was the close association of the faculty by family ties. Gustav Keppler has given examples of these interrelations at the time of Maestlin in his Keppler Familiengeschichte (II, pp. 137-38): Jakob Andreae's daughter Susanne was married to the Director of the Church Council,

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Few records remain to indicate exactly what Maestlin taught at Tübingen. Astronomy lectures were undoubtedly accompanied by his own textbook, the Epitome Astronomiae of 1582, printed for the second time soon after his return to the university (1588). As several manuscripts of Maestlin's deal with trigonometry, we can safely assume that he taught that subject along with astronomy. Euclid's geometry was a subject required of most students, and Maestlin certainly taught at least Book I of the Elements along with, perhaps, comments on Apollonius and Archimedes.[1] In a letter to Kepler dated 13 October 1616 (O.S.), Johann Strauss mentions that Maestlin was then teaching practical arithmetic and the first book of Euclid in that term.[2] Presumably, practical arithmetic, long an important part of the curriculum in German schools, was taught often by Maestlin. In Wolfenbüttel there is a manuscript treatise on

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Balthasar Eysengrün, while two of his grandsons, Valentin and Johann, were married to Agnes Elisabetha and Barbara Grüninger respectively, the nieces of Erasmus Grüninger the Younger, Maestlin's brother-in-law. Another grandchild of Andreae, Anna Maria Schütz, married Erhardt Cellius' son Johann. Maestlin's second wife was the daughter of Jacob Burckhardt. Hafenreffer married Agathe, sister to J.H. Brenz, who, in turn, married Samuel Hailand's step-daughter Barbara Kösch. Brenz's niece, Margarethe Gräter, became the wife of Christoph Heerbrand, elder son of the Chancellor, while Heerbrand's younger son married an in-law of Magirus. Hettler's son Josef married Heerbrand's daughter Margarethe. The Chancellor's grandson, Wilhelm Heerbrand, married Magirus' wife's sister Cordulla Essich and then married a Gerlach. Vranius married a niece of Heerbrand. Hailand's daughter Barbara married a son of Lucas Osiander. Planer married a daughter of Liebler, Agathe. Waigenmaier's son, Johann Baptist, married a niece of Ziegler. Ziegler himself was related to Veit Müller, one of Kepler's teachers. And finally, the wives of Gerlach and Brenz's son Johann were sisters. We might also remember that Maestlin's daughter, Anna Dorothea, married an Osiander. This maze of genealogy only underscores the closeness of the university community in the later sixteenth century, a factor that may have militated against Kepler's acceptance at Tübingen (see section 4.1).

[1]Caspar, Kepler, p. 48. There are also scattered references to Archimedes in the mathematical manuscripts in Stuttgart.

[2]GW XVII, No. 749, pp. 196-97.

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algebra that suggests an elementary course of lectures on that subject.[1] According to Zinner,[2] there is a manuscript in Erlangen containing Maestlin's lectures on the sundial, dating from 1613. In addition to these subjects, he may also have taught the elements of spherical trigonometry (for astronomical purposes) and possibly even the use of astronomical instruments. The contents of the Epitome Astronomiae suggest that much of his lectures on astronomy during this period was conventional (which is what he was paid to give) although Kepler says that Maestlin often mentioned Copernicus in his lectures,[3] indicating that he included more modern views than simply elementary Ptolemaic astronomy.

Maestlin's major writings date from his Heidelberg period, but he continued to produce shorter works, particularly disputations, at Tübingen. At least four works on the Gregorian calendar reform were penned by him after his return to Tübingen, including his most important work on that subject, the Alterum Examen of 1586. Disputations on eclipses (1596) and on the irregularities of planetary motions (1606) appeared within the next few years, the theses having been proposed by Maestlin. While not his own work, the Mysterium Cosmographicum of Kepler, printed in Tübingen in 1596 under his direction, was an opportunity for the older man to further discuss Copernican astronomy through his appendix to that work.

While at Tübingen, Maestlin continued to make observations, sometimes in the company of colleagues, students, and, in later years, his

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[1] Cod. Guelf. 80.1 Aug. 4°.

[2] Ernst Zinner, Verzeichnis der Astronomischen Handschriften des deutschen Kuturgebietes (Munich: C.H. Beck, 1925), p. 218. [Hereinafter cited as Zinner, Verzeichnis.]

[3] GW I, p. 9.

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son Gottfried. He seems to have taught well into his old age, although I have seen no evidence to suggest that he bore the responsibilities to the end; at least during the last years, Schickard aided him. Whether he taught full-time in his seventies or not, he still observed when he could: a manuscript survives in Stuttgart with his observations of the lunar eclipse of 1628, made during his seventy-eighth year.[1] In all, he taught at his alma mater for forty-seven years after his return from Heidelberg.

1.5 Friends, Pupils, and Correspondents; Maestlin the Man

Of his teachers at Tübingen, Maestlin was closest to Samuel Hailand, his ethics teacher, with whom he corresponded in the years before 1580, mostly concerning his Ephemerides Novae; he also wrote to Martin Crusius. The elder Hafenreffer was a close friend after Maestlin's return to Tübingen, although the theologian was staunchly anti-Copernican. Maestlin was on good terms with most of the Tübingen faculty, and letters to and from practically all of them survive. He maintained close contact with his own family but did not seem to have been particularly close to the Andreae or Heerbrand families.

Many of Maestlin's friends and correspondents were academics or scientists like himself. He exchanged letters with Tycho and his student Gellius Sascerides (1562-1612) but was closer to Helisäus Röslin (1544-1616), physician and astrologer, with whom he exchanged astronomical and chronological information. He knew the controversial Nicodemus Frischlin (1547-1590), who first printed Maestlin's tract on the New Star of 1572 and whose astronomical lectures were, in turn, commented

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[1] Cod. Math. $4^{o}15^{b}$ nr. 10.

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upon by Maestlin. He also corresponded with Herwart von Hohenburg, Kepler's friend and Chancellor of Bavaria, as well as with the number mystic, scholar, and engineer Johann Faulhaber (1580-1635) of Ulm. Johann Weidner, a schoolmaster of Schwäbische-Hall, and Georg Marius (1533-1606), Heidelberg physician, also kept in touch with him. Other members of the Heidelberg faculty remained friends after his removal to Tübingen. He was also close to both the Pfalzgraf Ludwig VI and his son's Protector and Regent, Johann Casimir (1543-92) as well as his own lord, Duke Ludwig III of Württemberg. The latter, especially, seems to have had a high regard for him. His successor, Duke Friedrich I (1557-1608), relied upon Maestlin's opinions in scientific affairs.

Of all Maestlin's students, the most important was Kepler. Kepler arrived in Tübingen in 1589, studying both mathematics and astronomy with Maestlin. He and Kepler were associated closely from that time until 1600, at which time the latter moved to Prague; however, their relationship continued, somewhat abated, until Kepler's death a year prior to his teacher's. Several other pupils of note who studied with Maestlin include the mathematician Georg Galgemair (died 1620); the linguist, mathematician, and inventor Schickard; Samuel Hafenreffer (1587-1660), son of the theologian; Johann Valentin Andreae (1586-1654); and Daniel Mögling (fl. c. 1620-30).

Maestlin the man emerges as an interesting and sympathetic figure. Physically he was large, like most of the Maestlins before him; from two surviving portraits, we can see what he looked like both in youth and old age. In both the Ephemerides Novae and Consideratio & Observatio there is a woodcut portrait made in 1578 (at the age of 28) which depicts an intelligent-looking young man with a beard, medium

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length hair but somewhat severe countenance. An oil portrait, which now hangs in the Aula at Tübingen,[1] was produced when he was in his seventies and depicts a stocky man with a well-trimmed beard and short hair; his eyes are smallish in the painting, however. Indeed, he seems to look vacuous as Koestler remarks.[2] In both portraits he is holding a pair of dividers before a celestial globe. Kepler referred to Maestlin's "bodily build," but neither Kepler's comments nor the portraits suggest that he was corpulent -- just large. In any case, he does not seem to have been averse to good food and drink.

That Maestlin was a very religious man is obvious from his letters and writings, but his piety was at most conventional, for rarely is there any hint of religious extremism, a prevalent characteristic of his contemporaries. He was not a firebrand like Andreae or Heerbrand. Perhaps his lack of fiery rhetoric contributed to his poor reception at Backnang during his short ecclesiastical career. His Lutheran partisanship is most evident in his works against the calendar reform, and he was sarcastic when dealing with the Roman hierarchy. In his correspondence, however, he shows a more conciliatory attitude toward religious differences: both Kepler and Helisäus Röslin held quite different views from him, but he never made a special point of them and maintained good relations with both. His favourite Biblical quotation, which appeared in many albums and

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[1]Reproductions of this painting can be found in Karl Stöckl (ed.), Kepler-Festschrift (Regensburg: Heinrich Schiele, 1930), I, facing P. 337, and in Edward Rosen's edition, Kepler's Somnium (Madison: University of Wisconsin Press, 1967) [hereinafter cited as Kepler, Somnium.] According to Steiff, "Michael Mästlin," p. 53n., another portrait in woodcut is in Cellius' Imagines Professorum Tubingensium.

[2]Koestler, The Sleepwalkers (Harmondsworth: Penguin, 1964), p. 270. [Hereinafter cited as Koestler, Sleepwalkers.]

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scrapbooks of his friends,[1] was a somewhat shortened version of Isaiah 40:

> All flesh is grass, and all the goodliness thereof is as the flower of the field. The grass withereth, the flower fadeth. Because the spirit of the Lord bloweth upon it . . . but the world of our God shall stand forever.

In some of his writings, Maestlin shows an apocalyptic spirit, suggesting that the End is near and men should repent and return to God, a view entirely typical of sixteenth-century Lutheranism. He does not, however, fill his correspondence with such thoughts and seems to remain generally optimistic despite occasional pessimistic relapses. While he often ends his works with a prayer, he clearly is not a preacher. Like Kepler after him, he was swayed from theological studies at Tübingen by the love for mathematics; Kepler sometimes lamented having left theology, but Maestlin never seems to have regretted leaving the church service for a mathematical profession.

We have seen that Maestlin was a devoted family man. He was also helpful to his friends as Kepler's case shows. Kepler's many requests for aid must have exasperated Maestlin at times, but for years he helped his former pupil unselfishly. He was generous even to those he did not know, such as Kepler's mother.[2] An example drawn from the Kepler correspondence will suffice: a Strassbourg student, Janus Gringallet, tells of a visit to Maestlin's home in a letter to Kepler of 2/12 October 1620.[3]

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[1]Examples appear in: WLB Cod. Hist. 4°333b-32 dated 21.1.1623; Cod. Hist. 8° 157, 134R dated 9.11.1620; HB XV 3,249R dated 21.1.1623 for Johann Friedrich Ochsenbach; also in UT MSS. Mi XII 27a, Mh 770/70, and Mh 967.

[2]See below, section 4.1.

[3]GW XVIII, No. 896, pp. 45-6.

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Gringallet was first turned away from the door as Maestlin's housekeeper thought the student was a beggar, but when the older man learned the truth, he took Gringallet in as a houseguest and introduced him to the worthies of Tübingen. Yet Maestlin did not even know the man.

Kepler and scholars like Schickard in Tübingen often consulted Maestlin's library which, by all accounts, was well stocked with books on a variety of subjects, especially astronomy. His home was open to his friends and he was generous, although not prodigal. His correspondence indicates that he was mild mannered, religious, intelligent, and sometimes a courageous man. Like many sixteenth-century scientists, he could be quite scornful of views with which he disagreed but full of praise for those that interested him. He lacked the meanness of spirit that seems to typify many of Tycho Brahe's affairs. Prudence was a much-admired quality; when his friend Röslin died, Maestlin remarked to Kepler that the man had not been prudent enough, despite his obvious religious faith.[1] (Röslin was a Schwenkfeldian, not a Lutheran.)

While Maestlin seems generally to have been good natured, he had periods of melancholy, apparently stemming from family problems or tragedy. As he became older, he also occasionally became grumpy, as his later letters to Kepler indicate. He was no curmudgeon, however.

There are several references in the correspondence of Kepler which show that in his later years Maestlin was ill from time to time. Samuel Hafenreffer reported in 1605 that Maestlin was "seriously ill."[2] At one point, his health was so poor that J.B. Hebenstreit reported (on 28 October 1620, O.S.) that Maestlin had died of apoplexy.[3] He may

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[1] See below, section 4.2.

[2] GW XV, No. 396, p. 354.

[3] GW XVIII, No. 901, p. 52.

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have been troubled by a heart condition throughout his later life, but he lived eleven years beyond Hebenstreit's "death notice." Death finally came for the old professor of mathematics on 20/30 October 1631 in Tübingen.[1] Having just passed his eighty-first birthday, he had outlived two wives, many of his children, friends, colleagues, and students. The oratio funebris was delivered in Tübingen by his faithful student Schickard, then Professor of Oriental Languages.[2] Since Schickard had aided his master during the last years, after Maestlin's death he was given the lectures on astronomy while Eberhard Schultheiss was given the lectures on Euclid. Until Maestlin's death, he had taught, in one capacity or another, for sixty years.

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[1]According to the Tübingen records. Maestlin's death year is given as 1590 by Cates, Dictionary, p. 699 and Chalmers, Dictionary, XXI, p. 99. Zedler, Universel-Lexikon (Leipzig and Halle, 1739), XXI, p. 809, gives 1635. Hellman, Comet of 1577, p. 139, gives 20 December 1631, relying upon Favaro, NE XX, p. 478. Frisch, F I, p. 188, gives a date of 16 October 1631.

[2]Steiff, "Michael Mästlin," p. 49n. The oration is now lost.

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CHAPTER II

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CHAPTER II

THE SCIENTIFIC INTERESTS OF MAESTLIN

2.0 Introduction

Before turning to Maestlin's astronomy, I will deal with those interests of his in other branches of science, although most of them relate to astronomy. First, he was deeply involved in the debate over the Gregorian reform of the calendar. I have prefaced a survey of his thoughts with a resumé of attempts at calendar reform and details concerning Gregory's new canon. Related to calendars were ephemerides, of which he was the author of an important example of this genre of astronomical literature; his contribution is briefly described.

Second, like most scientists of the sixteenth century, Maestlin maintained a number of interests: mathematics, geography, and Biblical chronology. Since he held the post of professor of mathematics at both Heidelberg and Tübingen, he was bound to teach elementary mathematics as well as his primary interest, astronomy. His interest in geography was derived from astronomy as was, to an extent, his passion for chronological studies. It might be argued that Biblical chronology, the study of historical dating using Biblical information, was not scientific in the sixteenth century, but in his and some of his contemporaries' cases, chronology relied upon astronomy. I have, accordingly, treated this topic along with his other scientific interests.

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2.1 The Calendar and its Reform[1]

The calendar of the Christian nations in Europe prior to the Gregorian reform was a combination of the civil calendar established by Julius Caesar in 45 B.C., known as the Julian Calendar, and a modified version of the Jewish religious calendar. By this combination, the Church introduced complications into calendrical reckoning that remain even today, for the Julian Calendar was solar and the ecclesiastical calendar luni-solar. The civil calendar of the Roman Empire, and, subsequently, of Christian Europe, divided the year into exactly 365¼ days and introduced a leap year every fourth year as an adjustment for the quarter-days. It was recognized early, however, that this civil year was longer than the tropical year by a small amount. Early Christian computus writers recognized that the error amounted to about one day every 128 years.[2] A further difficulty is introduced by the luni-solar ecclesiastical calendar. Certain religious holidays depended on the periods of the sun and moon; for example, Easter day was set by most of the Church as the first Sunday after the first full moon occurring immediately after vernal equinox (the Paschal full moon). The vernal equinox, a solar event, and the Paschal full moon, a lunar event, did not remain in phase for the simple reason that the periods of the sun and moon are incommensurable. Several schemes, such as the 19-year (or Metonic) cycle, the 84-year cycle, the 532-year cycle of Victorius of Aquitaine, and others were introduced to calculate Easter from

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[1]I have employed a number of works on the calendar for this section. Two useful books are: P.W. Wilson, The Romance of the Calendar (New York: Norton, 1937), and J. Le Boyer, Traité complet du calendrier (Nantes: Mellinet-Malassis, 1822), [hereinafter cited as Le Boyer, Traité.]

[2]The Julian year is $365^{d}\ 6^{h}$ while the tropical year is

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astronomical events. None was quite adequate, a fact recognized by most learned writers on the calendar during the Middle Ages. Roger Bacon suggested employing the Islamic scheme of a 30-year cycle and noted that the date of the vernal equinox was moving backward due to the error in the Julian calendar. He sent his advice to Pope Clement IV in 1271, but the Pope died the same year without acting on the proposal.

An attempt by the Papacy to reform the calendar was made by Pope Clement VI who, in 1344, wrote to Firmin de Bellevalle and Jean de Murs asking for a learned opinion on reform. Their report, the Epistola super Reformatione Antiqui Kalendarii of 1345, suggested, among other ideas, that a leap-year day be dropped every 134 years to account for retrogradation of the vernal equinox.[1] Clement did nothing about the report. Pierre d'Ailly wrote a treatise on the problem, his Exhortatio ad concilium generale super Kalendarii correccione, which was discussed at the Council of Constance in March 1417; nothing came of the discussion. Cardinal d'Ailly had agreed with Firmin and Jean on the solar calendar and had made several suggestions for altering the dating of Easter and restoring the lunar calendar (the Golden Numbers, used to calculate Easter, were four days in error when he wrote). Nicolas of Cusa attempted reform at the Council of Basle somewhat later, but with no success.

Pope Leo X was interested in the reform of the calendar, and an abortive attempt was made with this end in view at the Lateran Council. A reform commission, headed by Paul of Middelburg (1446-1533) who was the

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$365^{d}\ 5^{h}\ 48^{m}\ 46^{s}$ in length, or an excess of $11^{m}\ 14^{s}$ a year, which gives about 1^{d} in 128 years.

[1]Firmin and Jean employed the Alfonsine Tables, which gave a value of $365^{d}\ 5^{h}\ 49^{m}\ 16^{s}$ for the tropical year, or a half-minute too long. The difference between the Alfonsine and the Julian values of the solar year amounts to nearly a day in 134 years.

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Bishop of Fossombrone and an astrologer of some note, reviewed the question and solicited learned opinions. Among those asked for comments was Copernicus, who declined, for he felt that the motions of the celestial bodies were imperfectly understood: his lifework was to be the study of those motions. Indeed, part of the rationale that Copernicus employed in his introductory letter to Pope Paul III in his De Revolutionibus Orbium Coelestium was that his new theory would aid in the restitution of the calendar. Paul of Middelburg himself had written, on the latter subject, a large treatise -- the Paulina, sive de recta paschae celebratione (1513) -- in which he suggests several ways to reform the calendar. Paul refused to accept a proposal of Cusa's that the accumulated error of 10 days in the Julian calendar simply be dropped, on the contention that the common people would be perturbed and confused. Interestingly enough, however, the possible confusion of the common people evidently did not enter into the problem when Gregory XIII had ten days dropped from the calendar in October 1582.

During the 1570's, an Italian, Aloisio Lilio (1510-76),[1] constructed a new cycle for the calendar with particular emphasis upon an improved epact cycle.[2] It passed into the hands of his brother Antonio, who was requested to place the work before Gregory's reform commission in Rome which he did in 1578. Lilio's treatise was studied by the commission which was headed by the German Jesuit astronomer Christopher Clavius (1537-1612). After a close study, the commission prepared an abstract entitled Compendium novae rationis restituendi Kalendarii which was duly transmitted to Catholic universities for their opinions. The chief

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[1]Variously spelled as Lilius, Giglio, etc.

[2]Detailed below, pp. 51f.

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comments came from Paul Fabricius, Professor of Mathematics at Vienna, in the same year. After more work, the reformed calendar was placed before Gregory XIII who, on 24 February 1582 (O.S.), promulgated his Bull Inter Gravissimas. With the Bull were a short Canones in Kalendarium Gregorianum Perpetuum and the promise of an explanatory text.[1]

It is well known that the chief adjustment to the calendar as far as the public was concerned was the disappearance of ten days after 4 October 1582. To keep the solar calendar in adjustment, a leap-year was to be dropped in any century year not divisible by 400. The new calendar was immediately adopted by the staunchly Catholic nations of Spain, Italy, France, Portugal, and Poland. In Germany, however, the Protestant Reformation created special difficulties, for, although the Imperial throne was Catholic, many of the more powerful princes were either Lutheran, Calvinist, Zwinglianist, or other sectarian Protestants. It is this religious conflict that helps to place Maestlin in the controversy.

The new calendar was somewhat more complex than the primary adjustments suggest. Before giving a summary of the Gregorian reform, I will describe the salient features of the ecclesiastical calendar prior to the reform. Since the Church had accepted the Metonic 19-year luni-solar cycle,[2] it had to have a method to reconcile the two periods to

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[1]The first major public exposition of the new calendar was that of Clavius: Explicatio Romani Kalendarii a Gregorio XIII. restituti (1603).

[2]Meton (fl. ca. 433 B.C.) gave a value of $365\ 5/19^{d}$ for the solar year (or $1/76^{d}$ larger than $365\frac{1}{4}^{d}$); in 19 years, this amounted to $6,940^{d}$. If this latter figure is divided by 235 (lunations), the Metonic lunar month is $29^{d}\ 12^{h}\ 45^{m}\ 57\frac{1}{2}^{s}$ or about 2 minutes' difference from the true figure. The Church accepted the Julian calendar solar year of $365\frac{1}{4}^{d}$ for calendrical reckoning instead of Meton's more accurate figure.

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calculate the dates of moveable feasts. The 19-year solar cycle in the Julian calendar equals $6939^{d}\ 18^{h}$ while 235 mean lunations (which are supposed to equal 19 solar years) equal $6939^{d}\ 16^{h}\ 31^{m}\ 48^{s}$, or an error of $1^{h}\ 28^{m}\ 12^{s}$ per cycle.[1] This amounts to one day in 310 years, but the error was not corrected prior to Gregory XIII. For the computation of new and full moons, a necessity for Easter reckoning, the Church relied upon Golden Numbers. These ran from I to XIX throughout a cycle: the first year was denoted I, meaning that the new moon fell on 19 January. The lunations then alternated through the year as "full" or 30-day lunations and "empty" or 29-day lunations (to account for the approximate lunation of $29\frac{1}{2}^{d}$). This made the next new moon fall on 18 February, the one following that on 19 March, and so on. The second year, or II, has the first new moon on 9 January. The Golden Numbers go on to XIX, the last year of the cycle. At the end of that year there is an excess of one day in the lunar period, so it is dropped -- hence, the so-called saltus lunae or jump of the moon. This brings the calendar back to Golden Number I and the new moon on 19 January. With the Golden Numbers, tables could be drawn up to show when the new moons would fall throughout the 19-year cycle, enabling Easter to be reckoned.

Computists recognized that seven lunations had to be intercalated over the 19-year period, for a solar year contains 12 lunations plus 11 days which accumulates into 33 days in three years, which is a 30-day lunation plus 3 days. So these seven lunations were added at various places in the cycle and called "embolistic" months, and the years in which they fell were called "embolistic" years.

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[1]These periods from antiquity remained in force although many mediaeval and Renaissance scholars had better figures.

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Another calculating device was the epact. The epact is the age of the moon on 1 January, and it increases eleven days each year until the total age surpasses 29 or 30 days (a month). The epact is then the remainder. Thus, the epact for Golden Number I is XI; for Golden Number II, XXII; for Golden Number III, III; and so forth to Golden Number XIX, for which the epact is XXIX. The cycle then begins anew. Unfortunately, the epact was incorrect, for the moon's age on 1 January was not quite 11 days, giving an error of one day in 304 years. From the time of Caesar to Gregory XIII, the epacts were more than five days in error.

The central feature of Lilio's new cycle was the replacement of the Golden Number as the chief computational device and its replacement with a new epact cycle. The new system gave epact numbers to the days of the month. For January, the first was denoted as *, which replaces XXX (or actually zero); the second is XXIX; the third XXVIII, and so on in reverse to the thirtieth which is I, the thirty-first again being *. February began with XXIX and ended on the 28th with I, and March began with * and ended with *, like January. April was like February but with an extra day at the end, being denoted XXIX. After this, 1 May was XXVIII, and the calendar began to slip month by month until December, when the first day was XX and the last was XXIV. In the months of February, April, June, August, September, and November, one day had two epact numbers, which accounts for the slippage through the year. Certain other days had special designations: Lilio had 6 January as 25, XXV, and this was repeated on 6 March, 4 May, 2 July, 30 August, 28 October, and 26 December. For 4 February, he had 25, XXVI; and for 5 February he had XXV, XXIV, which he also had for 4 and 5 April, 2 and 3 June, 30 and 31 August, 28 and 29 September, and 26 and 27 November. By

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31 December, he placed 19, XX. With this complicated system drawn up in tables,[1] knowing the epact of the year, one could find the days on which a new moon would fall. If the epact of 1969 were XI, then by following the chart across the year for XI, the new moons would be found on 20 January, 18 February, 20 March, and so on. These days do not correspond to the astronomically calculated new moons but to new moons employed for calendrical reckoning, and they can be several hours in error.

To find the epact of a year, the calculator must add 11 days for each year after a known epact. A recent example: if the epact of 1969 were XI, then the epact for 1970 would be XXII, and for 1971 it would be XXXII; but as 33 surpasses 30 by 3, the epact is actually III. Without knowing an epact year, a table should be consulted as the calculation could be difficult. The Julian calendar was much simpler in this aspect, for if the Golden Number of a year were known, one multiplied it by 11: if the product were less than 30, that was the epact; if it were more than 30, the product was divided by 30, and the remainder was the epact.

Along with the new epacts was the dominical letter which controlled when Sundays would fall in the year. Each year had a dominical letter from A to G, excepting leap years which were given two, the first having been employed in January and February, the second in the other months. Each day of the year had a dominical letter as well. Given the dominical letter of the year, one could find when Sundays would fall; for example, if the dominical letter for the year were A and 1 January

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[1]See Christopher Clavius. Explicatio Romani Kalendarii a Gregorio XIII. restituti. (Rome, 1603). The new epact cycle retained Roman numerals for all epacts except certain double-numbered days like 25, XXV, or 19, XX, etc. A good modern explanation of the Gregorian calendar may be found in J. Le Boyer's Traité.

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were A, 2 January B, 3 January C, etc. up to 8 January which would again be A or Sunday, then 1 January, 8 January, 15 January and so on would all be Sundays.[1]

With the completed Gregorian perpetual calendar, Easter could then be easily reckoned. If the epact of the year were known, then the epact day corresponding to it between 8 March and 5 April could be found. Taking, once more, 1969: the epact was 11, so between the two dates an XI is found for 20 March in the tables. Now 14 days had to be added to this date, giving 3 April.[2] The dominical letter for 1969 was E; 3 April, however, was not an E but a B. The next date for E was the 6th of April. Thus, 6 April was Easter Sunday.

2.2 Maestlin and the Polemic on the Gregorian Reform

The reception of the new calendar in Protestant Germany was mixed,[3] but in Württemberg, the intelligentsia responded strongly against the reform. The major opinion was penned by the Tübingen theologian who was to become one of Maestlin's colleagues, Lucas Osiander. His Bedencken Ob der newe Bäpstliche Kalender ein Nohtturfft bey der Christenheit seye . . . was published in Tübingen in 1583.[4] This work,

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[1]Dominical letters recur every 28 years; after a non-leap centenary year, the cycle will recur after 40 years.

[2]The 20th of March represents the date of the new moon (calendrical, not actual). Fourteen days after this date was the first day of the Jewish Passover (Nissan 15); Easter was the first Sunday after this date.

[3]See Ferdinand Kaltenbrunner, "Die Polemik über dei Gregorianische Kalender-Reform," Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften (Wien) Philos.-Hist. Classe 87 (1877), pp. 503-530. [Hereinafter cited as Kaltenbrunner, "Die Polemik".]

[4]For full title, see Bibliography. The work was published first by Gruppenbach in Tübingen in 1583 and in Heidelberg by Müller in 1584 along with Maestlin's Außführlicher und Gründtlicher Bericht and several

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as befitted a theologian of an orthodox Evangelical university, was of little scientific import but rather an anti-Papist polemic. In the Palatinate, however, a slightly more objective critique came from Maestlin. Emperor Rudolf II had sent letters from Prague on 20/30 December 1582 requesting opinions from his princes, and this task was turned over by Pfalzgraf Ludwig to his professor of mathematics at Heidelberg. In 1583, Maestlin responded with his treatise Außführlicher und Gründtlicher Bericht[1] which was sent by Pfalzgrag Ludwig to Prague in the same year. Maestlin's work became, in a sense, the credo of the Palatinate on calendar reform; that principality, hence, retained the Julian calendar.

The Außführlicher und Gründtlicher Bericht was a commentary on the necessity of calendar reform; it had only minor allusions to the astronomical weaknesses of Gregory's new canon. The scientific criticisms, promised by Maestlin in the 1583 work, appeared three years later. The first few chapters of his work deal with how the Julian and current ecclesiastical calendars are constructed, and, as in many works on calendar reform, he traces the history of both the calendar and its attempted reforms. In chapter four, he emmerates the errors in the Julian calendar (which was used for all business and religious affairs in the Empire), including the anticipation of the equinoxes and lunations with respect to the Golden Numbers; he also recognizes that the solar and lunar calendars are incommensurate. He notes that the reckoning of

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other Protestant opinions. Osiander was the son of the Reformer, Andreas Osiander of Nürnberg.

[1]For full title, see Appendix B, Item 12. The title has been garbled by several bibliographers, and Maestlin himself called the work Dialexis Germanica (letter to Johann Weidner, 23 July 1586 [O.S.], WLB MS Cod. Hist. 2°603, 344). [Hereinafter cited as Maestlin, Außführlicher und Gründtlicher Bericht].

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Easter is the chief calendrical problem in ecclesiastical affairs. From chapters five through eight, he gives reasons for the retention of the older calendar, concluding that:

> From each and every thing that has been described in the last four chapters, it is evident enough to understand that neither townsman nor peasant, neither holy nor worldly, neither learned nor unlearned together have need of the new de-formed Papal calendar. But, although in the old Roman calendar, still employed by us, some defects have crept in, they have not yet spread so far, nor by no means are they so important that they need a correction . . .[1]

One of Maestlin's arguments is that the new calendar would be confusing, not only to astronomers, chronologers, and other learned men but also to the common people. This concern for the common man is similar to that originally stated by Paul of Middelburg in 1513.[2] Maestlin recounts how Leo X, in preparation of the Lateran Council, wrote to all the universities of Europe for opinions on calendar reform. Gregory XIII, however, ignored the Lutheran universities[3] and presented his reform to the Reichstag in 1582 as a fait accompli. Clearly, to Maestlin, Gregory was meddling in the affairs of the Empire; calendar reform was just a method of attacking the Evangelical Faith.

Maestlin gives only a brief description of the mathematical and astronomical shortcomings of the Gregorian calendar (chapter eleven). The weakest point was the new epact cycle of Lilio, which Maestlin found to be viele subtile Künsst. Easter would not fall at the proper times when such a cycle was employed, and Maestlin gives several examples,

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[1]Maestlin, Außführlicher und Gründtlicher Bericht (1583), p. 101.

[2]Ibid., p. 154. Cf. Paul of Middelburg, Paulina, sive de recta paschae celebratione (Fossombrone, 1513), Lib. VII, cap. II, par. 1.

[3]Maestlin seems to have forgotten that there were no Lutherans in the time of Leo X.

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particularly when Easter was falsely reckoned.

The Außführlicher und Gründtlicher Bericht was a politico-religious attack by an astronomer on the Roman Church. Maestlin's reading audience was obviously meant to be Lutheran (especially the Pfalzgraf); only in his next work did he address his comments to scientific men of all faiths. Nevertheless, the work produced its intended effect: the Palatinate retained the Julian calendar.

Maestlin's second work against the Gregorian calendar reform appeared in 1586. The Alterum Examen,[1] written in Latin, was clearly intended for a different audience from that of the Außführlicher Bericht: it is shorter but deals more closely with the scientific disadvantages of the new calendar and continually speaks to "you mathematicians and patrons of the new calendar". Maestlin divided this work into two parts. In the ad lectorem page (end of the work), he claims that first he would show that the reform was "most perfectly abstruse" and full of intolerable and most crass errors. The second part would deal with the errors of the new calendar in detail after a resumé of the construction of the new calendar. In the preface (there is no dedication), he states that he has been an opponent of the reform since its inception, referring to his Dialexis Germanica (Außführlicher Bericht). He is surprised that no mathematician but himself had stood up against the multitude of errors. Thus, he must give a "necessary and perspicacious demonstration" of the failings of the reform. Since Gregory XIII had called for three

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[1]The full title was: Alterum Examen Novi Pontificalis Gregoriani Kalendarii, quo ex ipsis fontibus demonstratur, quod novum Kalendarium omnibus suis partibus, quibus quam rectissimè reformatum vel est, vel esse putatur, multis modis mendosum & ipsis fundamentis vitiosum sit. (Tübingen: Georg Gruppenbach, 1586.) [Hereinafter cited as Maestlin, Alterum Examen.]

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calendrical reforms -- the restitution of the vernal equinox to 21 March (to remain at that date in perpetuity), the correction of the rule of Golden Numbers by the introduction of a new epact cycle, and the establishment of Easter reckoning according to the traditional time (Sunday near the Paschal full moon), Maestlin's three chapters deal with these subjects respectively.

Maestlin notes that Gregory had to drop ten days from the calendar to bring it into alignment with the Nicaean Council's vernal equinox and that by then dropping three intercalary days in the centenary years not divisible by 400, the vernal equinox would remain at the same date. Maestlin shows, however, that the vernal equinox does not always fall on the 21st of March even in the new calendar and that it might come on the 20th, 22nd, and 23rd as well. That Gregory XIII could introduce a perpetual calendar lacking the proper astronomical tables seemed absurd to Maestlin. He was aware of the imperfection of the most important tables, the Prutenic and Alfonsine, and felt that accurate new tables would have to be constructed prior to the establishment of a perpetual calendar. Using the figures given by the new canon, he could show that the vernal equinox in the year 1900 would fall on a date different from that predicted by astronomical calculation.

If we allow the fixing of the vernal equinox at 21 March, says Maestlin, we would still have problems since the anticipation of the equinoxes is not equal, as assumed by the reformers, but uneven as shown by the Prutenic Tables.[1] He then turns to the method of finding the dominical letters by the solar cycle and gives a table of the

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[1]Copernicus had accepted a non-uniform anticipation of the equinoxes; it is now known that precession is essentially uniform with only minor variations.

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equation of the solar cycle. He attacks the new calendar on the grounds that the anticipation of equinoxes was based upon the mean motion of the sun.[1]

The heart of Maestlin's argument against the reform lies in the next two chapters. As the epact cycle is the major innovation in the Gregorian reform, he examines whether the cycle can predict the times of the new moon and whether it can give correct termini paschales. He explains the use of the Golden Numbers and epacts (with tables). The older use of these could not give correct dates, and Maestlin asks whether the new cycle of Lilio was an improvement. The dates for 1584 to 1586 are examined with comparisons between the new canon and astronomical calculation -- from the Prutenic Tables -- and discrepancies are found. For 1585, the Golden Number was 9 and the new epact XXIX. The traditional method would have given 26 August for the new moon and the new calendar 25 August, 4 a.m., while astronomical calculation gave 25 August, 9 a.m. -- a five-hour error. The authors of the calendar excused themselves, Maestlin says, by saying that a concordance between heavens and calculation cannot be attained, a thesis which he rejects.

Since the new epacts gave incorrect new moon dates, they likewise produced incorrect termini paschales. Maestlin produced a table of the Golden Numbers, epacts, and termini for the years between 1500 and 1700, compared with astronomically-calculated termini, and in two hundred cases he found 112 errors. He suggests that the termini be calculated astronomically, giving a table of Easter limits at the time of the Nicaean Council.

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[1]See below, p. 61.

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In the third chapter, Maestlin turns to the question of whether the reformed calendar places Easter on the Sunday nearest the Paschal full moon or on the Sunday closest to 21 March (the Nicaean Council vernal equinox). Several Easters in the new reckoning fell on full-moon days (being Sundays), not the subsequent Sunday; therefore, the authors of the reform fell into heresy. Worse still, some Easters in the new calendar fell before the full moon. For example, in 1527 the terminus was 26 March and the dominical letter B, so Easter would fall on the 27th and the full moon on the next day.[1] Occasionally Easter fell during the third quarter of the moon. So in 1629, the new terminus would be 8 April, and (the dominical letter being G) Easter would thus fall on 15 April. But the astronomical terminus would be 7 April, giving 8 April as the date for Easter which was not in the third quarter of the moon. Rather than clarifying the erroneous Easter reckoning of the old ecclesiastical calendar, the new canon simply created new errors.

In his conclusions, Maestlin becomes vehement. He has shown that the calendar of Gregory XIII is anything but perfect, absolute, perpetual, and correct as claimed by its proponents. Indeed, he says, "if you wish to find a worthy epithet to apply to the Gregorian Calendar, a very correct one would be A VILE MEDLEY OF ALL ERRORS."[2] The "exquisitely subtle" canon of epacts had failed to produce a perpetual calendar. Was Gregory trying to order even the sun and moon? He doubted that the Pope and author of the new calendar were unaware of the errors in the canon, for he thought of the Pope as an intelligent man. To Maestlin's thinking, the Pope obviously had ulterior motives. He felt that perhaps

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[1]This is a curious example, since 1527 was long before the reform.

[2]Maestlin, Alterum Examen, p. 50.

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the author was ashamed to give the reasons behind his calculations, for he knew that they were incorrect. The choice of 1582 for the reform was perplexing: the year was neither a centenary nor a bissextile year, and to drop ten days in October would be absurd. Why not February? Had February been chosen, however, Maestlin thought, Easter still would have fallen on the wrong day. And although the author must have been aware of his straying from the Nicaean pronouncement, he did nothing about it. Maestlin's final remarks are directed toward an anonymous writer, C.F.D., Johannes Rasch of Vienna, and Johannes Busaeus, a Jesuit at the Moguntina Academy.

While the language of the Alterum Examen is more subdued than that of the Außführlicher Bericht, it conveys a great deal of sarcasm; Maestlin often capitalized on the statements of Pope Gregory to ridicule them. He is particularly sarcastic toward the mathematicians and astronomers who acquiesced in the reform although they must have immediately seen the errors in the new canon.

The Alterum Examen was attacked the following year, not by Clavius or the Roman mathematicians but by Father Antonio Possevino[1] in his Moscovia,[2] in the fourth section "De anni et paschae emendatione." The appearance of the Moscovia brought Maestlin once again into the fray with his Defensio Alterius[3] of 1588, a point-by-point rebuttal of

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[1]Antonio Possevino, born in 1534, became a Catholic prelate and private secretary to Cardinal Gonzaga, and a biographer of the Gonzaga family. After studying at Padua, he became a Jesuit; as a Church emissary, he visited Eastern Europe and Russia about 1580, spending time in the court of Ivan IV where he wrote against the English merchants. He wrote on theology, philosophy, and politics. He died in Italy in 1611.

[2]Moscovia et alia opera de statu huius saeculi adversus Catholicae ecclesiae hostes (in officina Birkmannica, 1587).

[3]For complete title, see Appendix B, Item 15.

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Possevino. Maestlin notes that, although two years had passed since the appearance of his Alterum Examen, no mathematician, particularly Clavius, had attempted a rebuttal; instead, only Possevino's "most inept" attack had been published. Actually, Posevino had singled out Maestlin in only one paragraph of the Moscovia, and that paragraph lacks any scientific merit. Maestlin first defends himself from "a certain Antonio Possevino" who had called him a heretic, but he was not frightened by such talk since he felt that Jesuits all speak of Protestants in such terms. Possevino claimed that Maestlin's work contained nothing of worth, to which Maestlin countered with a resumé of the errors in the Gregorian calendar. The first error that he discusses is the one which states that the vernal equinox falls on the 21st of March in all years. The Prutenic Tables show that the equinoxes are not equally anticipated as assumed in the new canon of Gregory XIII, and Copernicus himself, in Book III of De Revolutionibus, clearly showed this to be the case. Maestlin suggests that the solar anomaly should be relied upon, for the proper astronomical motion of the equinoxes could then be calculated. Granting that, the vernal equinox can be shown to fall on a mean date of 23 March, with a slow regression taking place in time. Indeed, the equinox rarely would fall on 21 March, as he showed in his earlier work; after about 10,000 years, the equinox would never fall on that date.

About half of the Defensio Alterius is a recapitulation of Maestlin's earlier arguments. He mentions the faults of the new epact cycle, relying upon his examination of the years 1584-86 and also points out that the cycle of Lilio cannot give the proper times of new or full moons. Easter reckoning is, therefore, inaccurate. The tone of this work is as sarcastic as the preceding one; Maestlin must have been eager to

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press the debate on the calendar to publish it since Possevino's short criticism was certainly not worth the effort to refute.

But Maestlin was actually waiting for Clavius. He was not disappointed, for in the same year (1588) Clavius finally published his rebuttal to Maestlin: the Novi Calendarii Romani Apologia adversus Michaelem Maestlinum Göppingenseum . . . tribus libri explicata (Rome, 1588).[1] Clavius had not seen Maestlin's Außführlicher Bericht but had read the Alterum Examen. In his reply, which was to the latter work, Clavius defends the use of cyclical reckoning (i.e. the new epact cycle) in the reformed calendar because the mean motions had to be relied upon. He knew that reliance upon the non-uniform motions of the sun and moon for calendrical reckoning would be difficult and confusing. He realized that cyclical reckoning was imperfect, but, considering the quality of the astronomical tables then available, he felt that little could be done to correct the problem. He admits that, if better tables eventually were to be constructed, the calendrical canon could be reckoned anew. Clavius next turns to somewhat weaker arguments: Jewish ceremonies were reckoned according to the mean motions of celestial objects, not the true motions, as the Bible shows. Furthermore, the greatest calendrical experts in Church history had spoken in favour of cyclical reckoning.

In actuality, Clavius' answer to Maestlin's attacks was the reaction of a practical man to picayune comments. He felt that, although the calendar may have introduced minor errors, it overall served its purpose admirably well. After all, the Easter-oriented festivals (e.g. Lent) would have been affected by a calendrical change early in the

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[1] I have not seen this work but here rely upon Kaltenbrunner's account in "Die Polemik", pp. 545ff.

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year, so Clavius felt that it was understandable why the calendar was not instituted until later in the year. He therefore attacked Maestlin's allegation that the Church was being devious in promulgating the reform in October 1582 and supported the Church as simply being prudent.

Maestlin wrote two further works against the calendar, both directed at Clavius' Apologia. The first, his Apologia examinum suorum was printed in Tübingen in 1593 and the second, Examina eorumdemque apologia, in 1597.[1] I have found no traces of either work. Clavius answered neither attack, but in 1603 he published his chief work on the new calendar, Explicatio Romani Kalendarii a Gregorio XIII. P. M. restituti. Maestlin entered the fray no more but was never convinced to adopt the new calendar. Both Tycho and Kepler knew of Maestlin's attacks on the reform, and Kepler defended the new calendar in several letters to his teacher.

Maestlin's opposition to Gregory XIII's reform, then, was based on religious, political, and scientific factors, the first two of which are clearly evident in the Außführlicher Bericht. His religious misgivings grew out of the resentment of a staunch Lutheran against Catholic meddling in church affairs, while his argument opposing the political implications of the new calendar arose from its inconvenience: his feeling was that, although the old calendar was not perfect, at least it was universally understood and employed. He felt that there were simply no good reasons for supplanting the old calendar with a new one. Maestlin's scientific opposition, on the other hand, was set forth in his Alterum Examen, many of his arguments being certainly picayune. He

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[1]This latter work was probably the one to which Maestlin refers in a letter to Kepler in 1596 saying that the Academic Senate had reprimanded him for not completing the work on time.

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could not have failed to realise, like Copernicus before him, that if any calendrical reckoning were to achieve great accuracy, it ultimately would have to rely upon a much superior astronomy. Thus, his resorting to picayune arguments indicates that his continuing fight against Possevino and Clavius was more of a political and ecclesiastical, rather than a scientific, nature.

2.3 Maestlin's Ephemerides

Ephemerides, tables setting out the motions of the sun, moon, and planets, seem to have originated in Babylon. Whether the Babylonian ephemerides were based upon a specific theory is debatable, but since the time of Ptolemy, all ephemerides have been computed from astronomical tables drawn up from theoretical canons. During the Middle Ages, ephemerides were based upon such tables as those of Alfonso X of Castile (13th century). Improvements in the tables began in earnest with the work of the Vienna astronomical school founded by Henry of Hesse; the school's most famous exponents included Johann von Gmund (1380-1442), his student Georg Peurbach, and the latter's student Regiomontanus (Johannes Müller, 1436-1476). Regiomontanus printed his own ephemerides at Nürnberg, the works becoming the models for future ephemeris calculators. While all the ephemerides printed in the late fifteenth and early sixteenth centuries were based upon Ptolemaic theory (generally from the canons of Alfonso), the Copernican theory offered a new basis for astronomical tables. Erasmus Reinhold (1511-1553), professor at Wittenberg and sometime colleague of Rheticus, published in 1551 his Tabulae Prutenicae Coelestium motuum, drawn from Copernican theory.[1]

[1]The tables were not strictly Copernican but somewhat eclectic. The accuracy of the Tabulae Prutenicae was not much better than that of Alfonso's tables.

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The tables became popular quickly: John Field employed them for his ephemeris of 1557 in England ("juxta Copernici et Reinholdi canones"),[1] while in Germany ephemerides were drawn up from Reinhold's work by Johann Stadius (for 1554-70), Cyprian Leowitz (for 1556-1606), and David (Tost) Origanus (for 1595-1630). Perhaps the most popular ephemerides were those of the Italian Giovanni Antonio Magini (for 1581-1630). In 1580, Maestlin joined this group by publishing ephemerides also based upon Reinhold's.

The work, Ephemerides Novae, Ab Anno Salutiferae Incarnationis 1577. Ad Annum 1590. Supputatae ex Tabulis Prutenicis, per M. Michaelem Maestlinum Goeppingensem,[2] was printed by Gruppenbach in Tübingen. The ephemerides were calculated for the longitude and latitude of Tübingen (which Maestlin placed at 29° 43' West, 48° 24' North). Maestlin's ephemerides were calculated from 1577 in order to be a continuation of the ephemerides of Johann Stadius which ended, according to Maestlin, in 1576.[3] Since Stadius had not produced a sequel, Maestlin took it upon himself to supply the extended calculations.[4]

The work was dedicated to the Rector and Senate of Tübingen University, the dedication date being 22 August 1579. Maestlin had applied for and received a Diploma of Privilege from Emperor Rudolf II. This

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[1]J.L.E. Dreyer, A History of Astronomy from Thales to Kepler (New York: Dover, 1953), p. 346. [Hereinafter cited as Dreyer, History of Astronomy.]

[2]Cited as Maestlin, Ephemerides Novae.

[3]There were two editions of Stadius' Ephemerides: his Ephemerides for 1554-60, calculated for Tübingen, were published in Cologne in 1556; a new edition, with ephemerides for 1554-76, appeared at Cologne four years later. Maestlin's work was a continuation of the latter.

[4]Stadius died in 1579.

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document, the contents of which are described below,[1] was printed with the book. Maestlin praises the science of astronomy (as well as the university) and comments upon the basis of his work, the Tabulae Prutenicae:

> But yet it is admitted that they are not themselves exact and do not satisfy the appearances exactly, as in nearly every star, Mars being chiefly subject to [the errors] so that it is sometimes seen to depart nearly two degrees from the calculated position, and in the case of the moon, whose calculated position sometimes anticipates the heavens by an hour, as I have observed several times during eclipses; indeed, this dissonance arises not from the absurdity of the hypotheses (as it seems to some), nor principally from the equation of the anomaly in badly constructed tables, but the error comes from the observations themselves, which are the fundamental means used in demonstrating the appearances of the anomalies.[2]

The theoretical basis of the calculations of planetary motions (i.e. the Copernican hypothesis) was quite acceptable to him; the mathematical canon (i.e. Reinhold), he felt, could be improved if the parameters of planetary motion were accurately determined by observation. Maestlin declares that he is diligently observing to help correct this weakness in astronomy and describes the quadrant (measuring in minutes of arc) and cross-staff which he built himself[3] for that purpose.

After epigrams by Hieronymous Wolf and Martin Crusius, Maestlin includes two letters, one from Wolf dated 15 March 1577 concerning the forthcoming ephemerides and one from Helisäus Röslin, dated 18 October 1578. Röslin's letter concerns the comet of 1577 but arrived after Röslin read Maestlin's comet treatise, hence its inclusion in Ephemerides Novae.[4] With the preliminaries disposed of, Maestlin turns to the canons

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[1]Section 3.4.

[2]Maestlin, Ephemerides Novae, dedication,).(4r.

[3]See below, section 3.1.

[4]See section 4.2.

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of his work. Rather than write a fresh explanatory introduction to the tables, he includes Regiomontanus' own commentary on ephemerides, the section being entitled "Ioannes De Monte Regio Praeclarissimi Mathematici et Astronomi celeberrimi Commentarium in Ephemerides, cum additionibus." As Regiomontanus' text is terse, Maestlin expands and clarifies each passage, employing examples where necessary. Regiomontanus was not a Copernican, but by 1580, Maestlin was. He says that he will follow Copernicus for his astronomical theory since the heliocentric hypothesis is truer and more certain than the older ideas which he had shown with his observations of the comet of 1577.

While astrology was an integral part of Stadius' ephemerides, it had no place in those of Maestlin: "We consecrate our studies to astronomy rather than to astrology; we do not dedicate ourselves to the writing of a commentary on astrology. You, then, Candid Reader, enjoy this our astronomy."[1] As I will show below,[2] this attitude was typical of all Maestlin's astronomy.

Following the introductory material are the tables drawn from Reinhold and adapted for the longitude and latitude of Tübingen. From these tables Maestlin constructed his ephemerides. He gives information on all the visible eclipses at Tübingen for 1577 to 1590 and then completes the work with a daily ephemeris for the thirteen-year period.

The Ephemerides Novae spread throughout Europe. Its publisher, Georg Gruppenbach, writing to Maestlin in 1582, reported that he had sent a number of copies to Italy.[3] Tycho Brahe owned a copy of the

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[1]Maestlin, Ephemerides Novae, commentary, A4 v.

[2]See section 3.4.

[3]Cod. Guelf. 15.3 Aug. 2°.

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work,[1] and Magini, if he did not actually own a copy (which is unlikely), certainly heard of it through Thomas Finck of Flensburg.[2] The Ephemerides Novae was not only an addition to the small group of works based upon Reinhold's but also the only one of this genre penned by a believing Copernican. And while the Ephemerides Novae would be employed chiefly by astrologers and physicians for computing horoscopes, its author was writing, rather, for an audience of practising astronomers.

2.4 Maestlin as a Mathematician and Geographer

The earliest extant mathematical work written by Maestlin is a treatise entitled "Annotata in Euclidis Elementorum Geometriae Librum Primum" dated 1570.[3] The treatise is accompanied by several leaves of a late mediaeval or early Renaissance copy of Euclid; the fragment is named "Supplementa in Libros Euclidis"[4] and, according to the notes describing the Collectanea Mathematica, came from the library of Philipp Apian. Presumably the manuscript was purchased by Maestlin along with Apian's other books upon the latter's death.

The "Annotata" deals with only the first book of Euclid. Maestlin includes the Greek text and a Latin translation for some of the postulates and common notions (but none of the definitions), giving a short explanation for each. He then goes through Book I proposition-by-

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[1] See section 4.3.

[2] Finck, writing to Magini on 8 February 1586, called his attention to the fact that Maestlin had computed the longitude difference between Antwerp and Tübingen (in a table of differences of latitudes and longitudes of the chief cities of the world and Tübingen). In: Carteggio Inedito di Ticone Brahe, . . . con Giovanni Antonio Magini. Edited by Antonio Favaro (Bologna: Nicola Zanichelli, 1886), p. 191.

[3] Cod. Math. $4^{o}15^{b}$ Nr. 2.

[4] Ibid., Nr. 1. The text is entirely in Latin.

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proposition, giving the Greek and Latin text, an explanation, diagram, and in many cases, numerical examples. For the propositions in the later parts of the manuscript, he includes examples employing roots with modern radical signs. The treatise stops abruptly with Proposition 44 and does not, therefore, reach the Pythagorean Theorem. I suppose that the final sheets have been lost as the rest of the work is intact.

Maestlin mentions few writers in the treatise; among the noteworthy were Aristotle, Proclus, Theon, and Giorgio Valla.[1] The actual purpose of the treatise is unclear. It is neither an independent commentary on Euclid nor a student "crib". He was still a student at the time of the writing of the treatise, and he may have prepared it for students (it will be remembered that he was a tutor in mathematics on graduation in 1571).

There is only one complete extant work on algebra by Maestlin -- the Algebra sive Brevis et perspicua descriptio regulorum Cossae[2] -- which, according to the title page of the manuscript, was written in 1603. The work does not seem to have been printed. On the first leaf is the inscription "Pro Johanne Valentino Andreae Herrenbergensis" which is followed by a passage in Greek. Since the manuscript is not in Maestlin's hand, it must have been copied by a third party and presented to Andreae. Andreae himself published a work in 1614, his Collectanea Mathematica, representing some of Maestlin's views on mathematics.[3] The Algebra

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[1]Maestlin refers to Aristotle's Ethics and Problems in Mechanics, Proclus' commentary on and Theon's edition of Euclid's Elements, and Valla's collection of proofs and propositions in his De expetendis et fugiendis rebus (Rome, 1501).

[2]Cod. Guelf. 80.1 Aug. 4°.

[3]Hans Aarslef, "Johann Valentin Andreae," DSB I, p. 159. I have not seen Andreae's work.

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may have been part of a collection of Maestlin manuscripts which came into Andreae's hands (along with some chronological works). The algebra text is clearly a school textbook, not an original work on algebraic theory, and may represent lecture notes given in or before 1603. The first half of the treatise deals with fundamental arithmetical operations such as the extraction of roots, multiplication, division, addition, subtraction, and fractions. The second half begins with the operations of "cossae" with a short discussion of the types of equations. Maestlin then gives his types of equations with operations, demonstrations and examples.

Maestlin considered algebra as a part of arithmetic and named Geber its inventor.[1] The first chapters on fundamental operations include a discussion of binomial coefficients with a table (Pascal's triangle). His version of Pascal's triangle is the then commonly known one, and it probably derived from earlier German mathematical treatises by Peter Apian, Stifel, or Scheubel[2] or, more probably, from all three. Maestlin, like his German predecessors, employs both the "plus" and "minus" signs. His notation is definitely not that of his contemporary, Franciscus Vieta (François Viète, 1540-1603), however, for Maestlin employs different symbols for unknowns. In his discussion of equations, he divides equations into "simple" and "quadratic," the simple equations

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[1]Cardano, in his Ars Magna of 1545, claims the invention was by al-Khworizmi, in that period the more commonly accepted originator of algebra. See Girolamo Cardano, The Great Art. Trans. T.R. Witmer (Cambridge, Mass.: M.I.T. Press, 1968), p. 7. Cf. Maestlin, Algebra, p. 1.

[2]Peter Apian first published the triangle in his Eyn Newe Unnd wolgegründte underweysung aller Kauffmanss Rechnung (Ingolstadt, 1527); the triangle also appears in Michael Stifel's (1487-1567) Arithmetica Integra of 1544 and in Johann Scheubel (1494-1570), De Numeris et Diversis Rationibus (1545). Maestlin may have seen all three works. Apian was his own mathematics teacher's father and Scheubel had been one of Maestlin's predecessors at Tübingen.

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being the First Equation and the quadratics being the Second Equation, of which there are two species. An example of the First Equation is as follows:

> Two numbers are sought such that if the first be multiplied by 12, it produces the other -37. If the first be multiplied by 15, it produces the other +44. [solution] The first is made 1u, the other 1A; therefore, 1u times 12 equals 12u, which number fails to surpass the other by 37. Wherefore the other, or 1A is equal to 12u + 37; likewise, the first multiplied by 15 makes 15u, which exceeds the other by 44, wherefore the other, i.e. 1A, is 15u - 44, thus 12u and +44 make 3u equal to 81, and 1u equals 27, and 1A is 361.[1]

In other words, Maestlin has given simultaneous equations in two unknowns, 12u + 37 = 1A and 15u - 44 = 1A.

The second equation is given in terms of proportionality:

> We use the second equation of cossic arithmetic when, by the operation, we reduce the equation to three denominated cossic numbers which are distant from each other by proportion or, likewise, are spaced from one another by the same quantity . . .[2]

The proportionality arises in the geometrical proofs of the species (since Maestlin draws his proofs from Book II, propositions 4, 5, and 6 of Euclid). The first species is, in modern terms, the simple case of $N = ax^2$. The three cases of the second species of quadratics are analogous to Cardano's "cases composed of minors:" $x^2 + ax = N$, $ax + N = x^2$, and $x^2 + N = ax$.[3] While Maestlin's categories rely upon a different

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[1] Maestlin, Algebra (Cod. Guelf. 80.1 Aug. 4°), p. 44.

[2] Ibid., p. 52.

[3] This species is also defined in terms of proportionality: "Huisque species sunt tres casus, aut enim numeri duarum quantitatum maiorum sunt aequales numero quantitatis minima, aut numeri duarum quantitatum minorum pronunciantur aequales numero quantitatis maxima, aut numeri quantitatis maxima et minima, exeunt aequales numero quantitatis media." Ibid., p. 53. It is interesting that Maestlin, writing an elementary text, does not employ a mnemonic device to remember the cases; cf. Cardano's jingle (as Witmer translates it): Squeaxno, adtwix/ Noesquax, adsub/ Axesquno, subadsub.

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terminology than Cardano's, they are nonetheless based upon geometric proofs. After giving the species, Maestlin adds demonstrations and examples. As there is no discussion of cubic equations in the Algebra, it is likely that the work was intended as a school text for beginning students.

Several other examples of Maestlin's algebra are in the Stuttgart collection, the Collectanea Mathematica.[1] A short fragment of an algebra, entitled "Isagoge in Regulam Algebrae,"[2] gives several rules for equations and is an abbreviated version of his longer Algebra. Another group of scattered sheets with the title "Miscellanea Arithmetice et Algebraice"[3] includes some schematic diagrams of species of numbers taken from Peter Ramus' Arithmetic of 1555 as well as notes and rough drafts of a work on algebra which seems to be the same as the one in Wolfenbüttel. None of this last collection is in Maestlin's hand, however, and may represent a student's or amanuensis' copy. In the drafts is a reference to "Christophori Rudolphi libella," which doubtless means the Coss published by Christoff Rudolff (c. 1500-?) in 1525 and reprinted by Stifel in 1553-54. This work was the first major algebra printed in Germany in the sixteenth century. Since Maestlin, in the title of his Algebra, says that he has employed the best authors, his sources probably would have been Apian, Rudolff, Stifel, Scheubel, or similar German writers rather than Cardano and other Italian algebraists. He knew of Ramus' work and, as we shall see below, also knew of Vieta's writings.

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[1]The MS, Cod. Math. 4^{o} 15, also includes astronomical miscellany described below.

[2]Cod. Math. 4^{o} 15^{b} Nr. 7.

[3]Ibid., Nr. 3.

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Maestlin had a great interest in trigonometry, particularly spherical trigonometry. In the Stuttgart collection is a treatise entitled "Modo, ratio, & fundamenta Compositionis tabularum Directionum Regiomontanus et Rheinholdi"[1] which seems to have been intended for publication, although no work seems to have been printed. The work is a handbook to both Regiomontanus' Tabula Directionum of 1485 which includes sines for every minute of arc and tangents by degrees, and the trigonometric tables given by Reinhold in his Tabulae Prutenicae. Maestlin also gives examples and diagrams for solving plane and spherical triangles by tables. The manuscript is not dated.

Maestlin was somewhat restrained toward the introduction of logarithms. His student Kepler, on the other hand, was greatly interested in this new mathematical technique and, on learning its details, began work on a commentary and set of tables which eventually was published as the Chillias Logarithmorum in 1624. Maestlin first saw logarithmic calculations in a letter from Kepler in which he discussed the reduction of an eclipse observation. Maestlin could not discover the grounds of logarithmic calculations from the figures given and was thus suspicious of them. He would refrain from employing them, he replied, until he knew more: "Therefore, I do not make use of the calculation whose demonstration I neither believe in nor understand, but whose demonstration I know."[2] In his reply to the letter, Kepler gave Maestlin a short lesson on logarithms and even sent the manuscript of his new work to his old teacher in 1622.[3] Maestlin retained this manuscript

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[1] Cod. Math. 4^{o} 15^{b} Nr. 4.

[2] Maestlin to Kepler, 2/12 March 1620; GW XVII, No. 871, p. 423.

[3] Kepler to Edmund Gunter, 4/14 December 1623; GW XVIII, No. 964, p. 144.

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for more than a year without working on it until Wilhelm Schickard, upon Kepler's prompting, asked for the uncorrected work. He finally received it in 1623, although Maestlin was in no hurry to return it.[1]

Maestlin's procrastination in revising Kepler's manuscript may have occurred for reasons other than distrust of logarithms. The fact that he had obtained a copy of Napier's Mirifici Logarithmorum Canonis descriptio and had taken detailed notes from it indicates Maestlin's inclination to take the subject seriously.[2] In his notes, which include a proposition-by-proposition paraphrase of Henry Briggs' appendix on trigonometric uses of logarithms, Maestlin gives many examples of solutions, using logarithms, for spherical triangles (presumably for astronomical purposes) as well as solutions for several plane triangles.[3] While Maestlin has been thought to have been an opponent of logarithms, it seems, thus, more likely that he was suspicious of them only at first and on closer examination became more interested.

Among the more sordid mathematical controversies of the period was one touched off by the publication in 1594 of the Cyclometrica Elementa and Mesolabium by Joseph Justus Scaliger (1540-1609). This work purported to give solutions for the quadrature of the circle and the

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[1] Schickard mentions his difficulty in getting the manuscript from Maestlin in his letter to Kepler of 20/30 September 1623, GW XVIII, No. 962, p. 142. Kepler also mentions the delay to Philipp of Hesse in December of the same year saying that "dißer gutte alte Man" had come to no resolve and that the work had passed to Schickard. GW XVIII, No. 968, p. 151.

[2] Cod. Math. 4^{o} 15^{b} Nr. 3. Although the notes which are in Stuttgart are not dated, it is likely that Maestlin had the 1619 edition with the Mirifici ipsius canonis constructio appended. He probably made the notes after Kepler's letter in 1620.

[3] A few pages later, he continues with certain propositions for plane triangles, drawing upon chapter 19 of Vieta's Liber VIII Variorum Responsorum (1593).

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trisection of an angle with compass and ruler. Scaliger wrote contemptuously of other mathematicians for, as Montucla has noted:

> Not content with the fame he enjoyed as a profound scholar, he aspired to join the first rank of mathematicians. The discovery of the quadrature of the circle seemed to him an assured means of doing so: . . .[1]

Scaliger's work brought refutations from all quarters, particularly from the greatest mathematicians of the time such as Clavius, Adrianus Romanus, and Vieta (in his Munimen Adversus Cyclometrica Nova of 1594 and Pseudomesolabium of the following year[2]). Maestlin, who saw Scaliger's mathematical works, wrote a summary of his propositions noting the errors. This summary, a short work, is entitled "In Scaligeri Cyclometriam et Mesolabium Diversorum Authorum notae Examina et Epistola."[3] It includes not only Maestlin's "Examen" but also two letters from Henry Saville in London to Johannes Praetorius of Altdorf (dating 1595) and one from Maestlin to N. Lingelsheim, a Palatine counselor. Maestlin's letter is undated but probably was written in the same year. He outlines Scaliger's major propositions and gives both the classical example of the problem (drawn from Archimedes and Bryson) and the error of Scaliger's treatment. He clearly felt that Scaliger was out of his depth since:

> Vanity leads those who are lightly versed in geometry to write volumes. And he [Scaliger] might not find the refutations [of his works] worthy if they had not been by the greatest authorities of all the most learned men of our time.[4]

Nevertheless, he felt that such works were inevitable, for "they are

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[1]Jean Montucla, Histoire des Récherches sur la Quadrature du Cercle (Paris: Bachelier Père et fils, 1831), p. 205.

[2]Printed in Vieta, Opera Mathematica. Ed. Franciscus à Schooten (Leiden: Elzevir, 1646).

[3]Cod. Math. 4^{o} 15^{b} Nr. 5.

[4]Ibid., fol. 19.

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led by false and childish persuasions and thus deviate from the rules of truth."[1] Maestlin's arguments relied upon the mathematical works of Archimedes,[2] and he closes the letter to Lingelsheim with a flourish: "Long live Archimedes!"

Maestlin's interest in geography was an adjunct to his mathematical and astronomical studies. He wrote at least one work that dealt with geographical problems, his Disputationes tres astronomicae et geographicae of 1592, which is now lost.[3] If similar to his other works, however, the topics likely discussed in this work were those that pertain to astronomy: the measurement of distances on the earth's surface, climatic zones, whether antipodes can exist, etc., all subjects being familiar to astronomers.

Two appendices to the Epitome Astronomiae deal with geographical problems of measurement. The appendix to Book I, concerning the size of the earth, gives both the methods and measurements of Eratosthenes and Posidonius and the values of Ptolemy and al-Fargani. Maestlin shows how the diameter can be computed, given the circumference, by employing the proportional regulam detri ("Rule of Three") together with Archimedes' value of π, 22/7.(4) Given the circumference, in German miles, of 5400, the diameter of the earth would 1,718 2/11 German miles (and the radius 859 1/11 miles).[5] With these figures, Maestlin then shows that

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[1] Cod. Math. 4^{o} 15^{b} Nr. 5, fol. 19.

[2] It is likely that Maestlin possessed Federico Commandino's 1558 edition of Archimedes' works which included the relevant treatises.

[3] In Cod. Math. 4^{o} 15^{b} Nr. 3, "Miscellanea," there are notes on geography dated 1619, which may have been for lectures; they are not in Maestlin's hand, however.

[4] Archimedes' value of π was actually $3\ 10/71 < \pi < 3\ 1/7$.

[5] The values are the same as those employed by Tycho. He gives

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one degree of latitude covers 15 German miles.[1]

The appendix to Book IV is a discussion of the measurement of distances on the surface of the earth. Saying that this could easily be accomplished by means of trigonometry, he therefore gives the basic definitions such as sine, chord, etc. The best sources for this procedure, he notes, are Apian's Cosmographia and Caspar Peucer's De Dimensione Terrae and adds that the basic trigonometric problems can be solved with the regulam detri accompanied by the theorems and trigonometric values found in either Copernicus' De lateris et angulis triangulorum or Regiomontanus' De Triangulis.

Maestlin also looked into the problem of determining terrestrial latitude and longitude. The former could be found by either of two methods: 1) by observing the altitude above the horizon of a star on the meridian and then subtracting its declination (given in tables) from the altitude; or 2) by observing the altitude of the sun on the meridian at the equinox and subtracting that figure from 90°. In either case, the astronomer (or mariner) had to rely upon the accuracy of the tables as well as his own observing skill.

Employing the latter method, Maestlin found the altitude of the sun on the Tübingen meridian to be 41° 36' at the autumnal equinox of 1574 (13 September).[2] The latitude thus determined was 48° 24'. The

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no indication of the source of his values (certainly not Tycho). They may be mediaeval estimates taken from Apian.

[1]He notes that one German mile equals four Italian miles, one of which in turn equals 8 stades (1000 paces). As the German mile equaled roughly 4.5 English miles, Maestlin's value for the polar diameter of the earth is about 170 miles short of the modern value. His value for a degree of latitude (15 German miles) would be equivalent to 67.5 English miles.

[2]Given in Cod. Vindob. 10887. No mention is made of his observational method.

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latitude of his hometown, Göppingen, was found to be 48° 28' "approximately."[1] The present values are 48° 20' and 48° 40' respectively. In his Ephemerides Novae, he gives the latitude of Tübingen as 48° 31½', evidently from later observations.

Longitude was more difficult to determine. Prior to the invention of an accurate, portable chronometer, the astronomer relied upon timing eclipses and comparing his observations with the tables, or upon Gemma Frisius' lunar-distance method (proposed in 1514).[2] Even with all his eclipse observations, Maestlin did not re-compute the longitude of Tübingen but relied upon Stöffler's earlier estimate of 29° 45' from west (i.e., from the Isles of Fortune or Canaries).[3] Stöffler had employed the eclipse of 1504 and compared his time with that observed in Antwerp. He then added the longitude of Antwerp (from the Canaries) to the difference he calculated. For the table of geographic locations in his Ephemerides Novae, Maestlin relied upon Ptolemy's Geography, Copernicus' De Revolutionibus, and the observations of Bernard Walther, Stadius, and Gemma Frisius.

Maestlin was also interested in cartography, an interest no

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[1]Given in Cod. Vindob. 10887 under 7 April 1575. As this was not an equinoctial day, his approximation was based upon the calculated celestial altitude of the sun.

[2]Neither method is accurate without good ephemerides; the ephemerides of the period were based upon the Alfonsine Tables or Prutenic Tables, both of which were quite inaccurate at times.

[3]Friedrich Rüttel, writing to Kepler on 7 April 1613, gave the longitude of Tübingen as approximately 34° 30' from the west. This figure was based upon observations (by Tycho and others) of the 1598 lunar eclipse. (GW XVII, No. 649, p. 50.) Tübingen actually differs in longitude from the Canaries by 26° 35'; Stöffler's measurement was thus more accurate than Rüttel's.

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doubt stimulated by his teacher Philipp Apian who was an outstanding cartographer himself. According to Steiff,[1] there were in Stuttgart two copies of a map made by Maestlin for the duke of Württemberg. Printed by Ludwig Ditzinger in Reutlingen in 1601, the maps represented the journey of Duke Friedrich I to Rome in 1600. Steiff said the maps were not badly drawn but, rather, poorly oriented. Although Maestlin's name appears on both maps, it is unknown how much of the work was actually his. Any other cartographical attempts by Maestlin are unknown to me.

2.5 The Chronological Works

The study of Biblical chronology goes back to late antiquity and was discussed in works by a number of early Church fathers. These works, which attempted to find a concordance between Biblical events and those of Egypt, Greece, and Rome, were practically all non-scientific and oriented to a literal interpretation of Scripture. This situation prevailed during the Middle Ages and, as A.D. White stated:

> The same manner of accepting the sacred text which led Luther, Melanchthon, and the great Protestant leaders generally, to oppose the Copernican theory, fixed them firmly in this biblical chronology; the keynote was sounded for them by Luther when he said, "We know, on the authority of Moses, that longer ago than six thousand years the world did not exist." Melanchthon, more exact, fixed the creation of man at 3963 B.C.[2]

Both the Protestant and Catholic churches maintained the literal interpretation of Biblical chronology until quite recent times. Perhaps the high point in the Protestant treatment was the chronological work of Archbishop Ussher (in 1650) who set the creation at 4004 B.C., a date

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[1] Steiff, "Michael Mästlin," p. 54.

[2] White, Warfare of Science with Theology, I, p. 252.

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still adhered to by some sects today. Only when the archaeological and geological discoveries of the eighteenth and nineteenth centuries began to find acceptance did the literal view of Biblical chronology begin to fail.

Scientists in the sixteenth and seventeenth centuries were particularly addicted to the study of chronology. Kepler, Riccioli, and Newton were typical of those who contributed to the field; Michael Maestlin was another. His pious Lutheranism coupled with his interest in mathematics and astronomy were a perfect combination for the study of chronology. Although his chronological works were not published during his life, he exchanged a great deal of chronological information with his friends and students. Maestlin's correspondence with Kepler on the subject is large, and there are many references to chronological problems in letters to and from Helisäus Röslin (another serious chronologer), Duke Ludwig of Wirttemberg, Herwart von Hohenburg, and others. In the case of Herwart, the Bavarian chancellor was quite interested in Maestlin's chronological studies and, in his own treatise on the subject,[1] gave solutions to many of the problems discussed by Maestlin.

Röslin, in his Discurs von heutiger Zeit Beschaffenheit of 1609, attacked the astrological argument of Laurentius Suslyga (a Pole) that the Dionysian dating of the modern era was incorrect and that the birth of Christ should be set back to 4 B.C. Suslyga had been struck by the coincidence of the "fiery trigon" conjunction of Jupiter and Saturn[2] and the appearance of the nova of 1604. He reasoned that since

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[1]In Herwart's Novae, verae et exacte ad calculum Astronomicum revocatae chronologiae et capita praecipua (Munich, 1612).

[2]Jupiter and Saturn were in conjunction in Aries which, with Sagittarius and Leo comprised the "fiery trigon" of zodiacal signs. The

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this particular conjunction cycle recurs roughly every 800 years, then one such occurrence would have taken place about the year 800 (the time of Charlemagne) and its predecessor just before the beginning of the Christian era. Suslyga placed this last conjunction in 4 B.C. Coincident with that conjunction was the Star of Bethlehem, which heralded the birth of Christ, and the new star of 1604 was a counterpart to the Star of Bethlehem. If the latter celestial event took place in 4 B.C., then that year was the zero point of the Christian era and Dionysius was incorrect.

Kepler, replying to Röslin in his Antwort auff Röslini Discurs (1609), claims that Maestlin held the same opinion as Suslyga (which fact Kepler had only just learned) and that his teacher had stated his view in lectures and in public disputation.[1] It would seem, then, that Maestlin did not confine his chronological speculation and calculation to his private study but publicly taught and defended some of his ideas.

The first of Maestlin's two chronological works published posthumously appeared in 1642 in Lunebourg with the title Synopsis Chronologiae Sacrae Michaelis Maestlini Quondam Mathematici Tubingensis Celeberrimi cum Harmonia Vitae Iesu Christi. The work was published by Maestlin's student, Johann Valentin Andreae (grandson of the former

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two planets move in such a way that if they are in conjunction in Aries, they will again be in conjunction about twenty years later in Sagittarius, and twenty years later in Leo. This cycle repeats four times (240 years) and the conjunction cycle then moves into the "earthy trigon," (Pisces, Scorpius, and Cancer) for another 240 years, thence into the "airy" and "watery" trigons and finally back into the "fiery trigon." Accounting for precession, this greater cycle takes about 800 years. The "fiery trigon" cycle began anew late in 1603 as the two planets moved into Aries; by the autumn of 1604, not only were Jupiter and Saturn in conjunction, but they also closely accompanied in the sky by Mars and the bright new star -- an awe-inspiring spectacle.

[1] GW IV, pp. 129-130.

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Tübingen chancellor Jacob Andreae). The manuscript, in another hand (possibly Andreae's), is at Wolfenbüttel.[1] Andreae added a short dedication to Duke August II of Brunswick. The brief work (29 folio leaves) consists of three extended tables, the first giving the lengths of time from the creation of the world to different events leading up to the birth of Christ. The second table, the longest, is a chronological list of Biblical and historical events with dates given in B.C. and in time elapsed from the creation (which Maestlin dated as 4079 B.C.). Adam's birth is given as 23 October 4079 B.C.; the Flood took place in 2422 B.C. and the passage from Egypt in 1625 B.C. Maestlin's dating is more realistic for historical events and draws, no doubt, from the burst of historical scholarship in the Renaissance. The date of Solomon's accession is given as 1036 B.C. (compared with the modern estimate of c.971 B.C.) and the fall of Jerusalem as 606 B.C. (compared with 586 B.C.).[2]

Maestlin did not agree with the Dionysian dating of Christ's birth[3] but placed the birth in March of 4 B.C. Following the new dating of Christ's life, Maestlin arrived at a date for the crucifixion of 23 April 33 A.D.[4]

The third table given in the Synopsis follows the acts of Christ taken from the four gospels with variant datings given from the works of

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[1] MS Cod. Guelf. 84.3 Aug. 4°.

[2] Modern estimates are based, in part, upon the Assyrian and Babylonian records then unknown.

[3] Based upon the sixth-century calculations of the monk Dionysius Exiguus.

[4] Cf. modern estimates for Christ's birth are 6 B.C. and 4 B.C.; the crucifixion estimates are A.D. 29, 30, or 33. The dating of Christ's life still relies upon internal evidence from the Bible as there are no contemporary documents mentioning Christ. The date of Christ's birth is still extracted in the same manner as Maestlin did it.

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Chemnitz, Lyser, and Gerhard.[1] There is no commentary with the work, but the Synopsis was intended as a supplement to Maestlin's major chronological work.

In Wolfenbüttel there is a manuscript work by Maestlin entitled Miscellanea Chronologica, sive Quaestionum ex tabulis chronologicis clarissimi viri Michaelis Möstlini.[2] That this manuscript is incomplete is suggested by the table of contents which divides the work into two parts: the first part, being tables, includes chronological theses, synoptic tables, particular chronologies, the number of Biblical harmonies and mysteries in the preceeding tables, and a genealogy of the Patriarchs. The second part is called "Quaestionum Chronologicarum," all but a few questions of which seem to be represented by the manuscript. The work published by Samuel Hafenreffer, the Chronologicae Theses et Tabulae Breves . . . cum exegesi Quaestionum Chronologicarum (1641) may have been the entire manuscript.

The Quaestionum Chronologicarum contains more than 500 pages (folio) in another hand. A great number of works are cited including those by Roman and Greek historians, Josephus, and mediaeval and modern chronologers. After a proemium giving the reasons for studying Biblical chronology, Maestlin sets out a dozen rules for examining chronological questions. An example of such a rule is 'when confronted by two or more sources, rely upon the less obscure.' A further rule was 'rely upon

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[1]The works being the Harmoniam Evangelicum of Martin Chemnitz (1522-86), Continuationem Harmoniae Evangelicae a Martino Chemnitio inchoatae of Maestlin's friend and Wittenberg theologian Polycarp Lyser (1552-76), and Harmoniae Historiae Evangelicae of Johann Gerhard (1582-1637). The last two were continuations of Chemnitz's work. All three were prominent Lutheran theologians.

[2]Cod. Guelf. 26 Extrav.

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those historical works which you have some reason to believe are generally correct.' The use of celestial motions is also counselled: Maestlin would rely upon not only traditional tools of the chronologer but also his own astronomical knowledge. He was among the first to have employed astronomical evidence to corroborate internal evidence from the Bible.[1] A particularly interesting remark occurs with these rules, especially since it was made in a milieu of literal-minded Lutherans: he says to rely upon Biblical statements of historical events but to beware "quia vero etiam in Sacra Scriptura crebra numerorum discrepentia occurrit."[2]

Following the rules, Maestlin sets out to examine twenty-nine chronological questions in great detail. The first, on the epoch of Dionysius, is important because Maestlin disagrees with the dating system employed hitherto by the Church. The second question deals with the beginning of the world which, as we saw, was to be dated in 4079 B.C. The third question gives a history of the Deluge and is followed by many questions dealing with the dating of events in the lives of Abraham, Isaac, and the Patriarchs. After question nine, he gives ephemerides from the Exodus down to the time of Christ. Remaining questions cover Assyria, Babylonia, Greece, and Rome. Later Jewish history could be placed on an absolute scale, thanks to the astronomically-based reckoning from Nabonassar's reign (produced by Ptolemy).

The last two questions are concerned with the dating of Herod the Great's reign and employ the lunar eclipse said to have occurred late

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[1]The problem of establishing an absolute chronology must rely, among other things, upon astronomy. The Bible gives the relative chronology for many events and occasionally notes an astronomical event. If the chronologer can give the exact date of the astronomical event in question, the relative chronology becomes fixed.

[2]Cod. Guelf. 26 Extrav., p. 21.

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in his reign. According to Josephus, Herod the Great died in the thirty-seventh year of his reign,[1] just before Passover. The event was said to be heralded by a total lunar eclipse visible from Jerusalem. Maestlin reviewed the eclipses around the period from 3 to 5 B.C., finding total eclipses were visible from Palestine on 23 March and 15 September in 4 B.C. and on 13 March in 3 B.C. Since Passover occurs in the month of Nissan, the March dates were preferable; he then chose the eclipse of 23 March 4 B.C., which was best in concordance with other historical evidence on Herod's period. Christ was thus born in the Spring (probably March) of that year, which accords with the Biblical story.[2] Maestlin also rejected the use of 25 December as the traditional birthdate of Christ.

Kepler, in his Eclogae Chronicae of 1614, mentions that three years earlier Maestlin had dated the death of Herod in the forty-second year of the Julian era (or 4 B.C.); this information had not been known to Kepler earlier.[3] The last question (twenty-nine) is on the birth of Christ and the revised dates of His life. Dating the birth at 4 B.C., Maestlin was in a decided minority at the time: only Suslyga and the Jesuit Decker agreed, and Kepler claimed the date should be pushed back to 5 B.C.

In another chronological work, the De Anno Natali Christi of 1614, Kepler relates that Maestlin had presented chronological theses for the baccalaureate examination at Tübingen on 22 September 1602 (N.S.)

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[1]Josephus reckoned the Jewish year from Nissan; if Herod died in the 37th year of his reign, this would have occurred in A.U.C. 750, or 4 B.C.

[2]Cf. Matthew 2 and Luke 2.

[3]GW V, p. 297.

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but that Kepler was not informed of them for some time.[1] Whether these theses are the same as those in the first part of Maestlin's Chronologicae Theses et Tabulae Breves is not possible to ascertain, as the 1602 theses were never printed.

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[1] GW V, p. 207; see also GW V, p. 447.

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CHAPTER III

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CHAPTER III

MAESTLIN THE ASTRONOMER

3.0 Introduction

Although he had many interests, Michael Maestlin was, above all, an astronomer. In this chapter, I wish to examine Maestlin's astronomical thought and works. First his observations, especially those of the sun and moon, will be described, followed by an examination of his writings on the New Star of 1572 and on the comets of 1577, 1580, and 1618. His pedagogical works are then briefly described; and the final section is devoted to Maestlin's views on astronomy, with special regard to his adherence to Copernicanism.

Maestlin's life spanned years of great ferment in astronomical thought and achievement. Seven years before his birth, Copernicus had published his epoch-making De Revolutionibus Orbium Coelestium which not only eventually changed the science of astronomy but also influenced Maestlin's thought. With the works of Peurbach and Regiomontanus, a new interest was kindled in Ptolemaic astronomy, particularly in planetary theory. Regiomontanus, with his associate Bernard Walther (1430-1504), initiated an interest in attaining accuracy in observation for the purposes of constructing better tables for astronomers. The new observational interest reached a peak with the work of Tycho Brahe.

The world view held by practically all astronomers at the time of Maestlin's youth was a combination of Aristotelian celestial physics

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and the Ptolemaic mathematical astronomy of the Almagest. The two components were not entirely compatible, so the Renaissance astronomers relied upon a compromise version from the Middle Ages which descended from the physical view originally given by Ptolemy in his Hypotheses of the Planets. Roger Bacon introduced the ideas from the Arabs via Alhazen into the West in the thirteenth century. These ideas were best represented and commented upon chiefly by the Franciscans in the thirteenth century and by the Parisian school of astronomers in the fourteenth. The movement culminated in the Renaissance with Peurbach's Theoricae novae planetarum. The Renaissance astronomer held the world view represented by Peurbach and relied upon Ptolemy's Almagest for his mathematical techniques.

The observational astronomer had a variety of instruments at hand. These included quadrants, torquetrums, cross-staffs (or Jakobsstab), and armillary spheres. Not until Maestlin's sixtieth year was the telescope employed in astronomy, so, for most of his lifetime, the traditional naked-eye observations were the foundations of astronomy.

3.1 Maestlin as an Observational Astronomer

Maestlin was better known to his contemporaries as an outstanding observer than as a theoretician. For much of his life, he made what Bohnenberger called "schönsten Beobachtungen."[1] His earliest observation, if we are to believe Bohnenberger,[2] was of the solar eclipse of 1567 which was visible in Württemberg; Maestlin was then in the monastic school, and, while he may have seen the eclipse, he most likely did not

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[1] Bohnenberger, Lebensskizze Michael Maestlin, WLB Cod. Hist. 2°657, p. 5. [Hereinafter cited as Bohnenberger, Lebensskizze.]

[2] Ibid., p. 4.

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observe it scientifically. Of much importance was the routine observations made by Maestlin of the planets, sun, and moon over the years. A compilation of his observations from 1572 to 1596, with some additional entries into the first years of the seventeenth century, are preserved in Vienna manuscript 10887. Various eclipse observations are in the Stuttgart manuscripts Cod. Math. 2^{o} and 4^{o}. Only a cursory glance at Maestlin's observations is needed to see that solar and lunar astronomy consumed the greatest portion of his time and energy. It is interesting that the normally prudent and careful professor allowed his imagination to have free rein on the subject of the sun and moon, as we shall see.

Maestlin's printed works include at least one title purely concerned with the sun and moon -- his Disputatio de Eclipsibus.[1] This work, printed in 1596, is often mentioned in Kepler's Astronomiae pars optica (1604) as well as in his Somnium and Dissertatio cum Nuncio Sidereo. Maestlin discusses eclipses in his Epitome, drawing upon his own observations. He also discusses certain problems of the sun and moon in his disputation on the inequalities of motions[2] and, probably, in his three disputations on astronomy and geography as well.[3] Since these works no longer exist, we must rely upon fragments in Kepler's works and information from Maestlin's other works and letters to reconstruct some of his thought on the subject.

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[1]See Appendix B, Item 18. This disputation took place on 8/18 January 1596, although Crusius' diary stated 5/15 January. Maestlin presided while Markus Hohenfeld defended the theses. See Caspar, GW XIII, p. 400. Hohenfeld was one of three brothers from Austria who matriculated at Tübingen on 31 October 1589 (and therefore classmates of Kepler). Hermelink, Matrikeln. I, p. 673.

[2]See Appendix B, Item 22.

[3]See Appendix B, Item 16.

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It should be pointed out that Maestlin observed in the accepted manner of astronomers since antiquity: that is, he recorded the planets and moon in their aspects (e.g. opposition, conjunction, quadrature, etc.) and eclipses. He made a number of solar altitude observations at monthly intervals, especially at solstices and equinoxes,[1] but he did not attempt a comprehensive nightly observational programme like that of Tycho. Of course, a university professor like Maestlin had neither the time nor the requisite financial base to undertake such a programme, even supposing he would have found such a method scientifically useful.

Before a description can be made of the observations taken by Maestlin, it is necessary to enumerate the instruments he possessed. In his earliest observation of the new star of 1572, he employed only a thread (which was used to align stars). In an entry for 1577 in the Vienna manuscript, Maestlin describes a clock he had acquired which was weight driven and made 3,528 ticks an hour.[2] Presumably, the clock had a verge and foliot escapement, although only the wheelwork is described. Of course, the accuracy of his clock is impossible to assess, but he seems to have been pleased enough with it as it was employed for a great number of observations after 1577, particularly for eclipses.

In the entry for December 1579, Maestlin mentions that he had made a quadrant (measuring in minutes of arc) and a cross-staff, or astronomical radius, fourteen feet long. Both of these instruments are mentioned in his comet tract of 1580. The cross-staff was divided into

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[1]Taken at local noon (when the sun was on the meridian). No indication is given in the manuscript as to how these observations were taken.

[2]Ernst Zinner says 2,528 beats per hour. Deutsche und Niederländische Astronomische Instrumente des 11-18 Jahrhunderts (Munich: C.H. Beck, 1956), p. 435. Cf. Cod. Vindob. 10887, f. 9r.

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1400 parts along the staff itself and had fourteen cross-pieces variously divided into 10, 16, 20, 32, 40, 60, 80, 100, 160, 200, 300, 400, 600, and 800 parts. Considering the size of such an instrument, Maestlin undoubtedly had it mounted, although he does not describe any mounting. He also possessed a camera obscura, probably built by himself for solar observations. Bohnenberger claims that he also constructed celestial globes.[1] The quadrant is not described.

In Tübingen, Maestlin purchased a house up on the slope leading to the castle (now Burgsteige Nr. 7)[2] so that he could have an unobstructed view of the horizon. He also observed from the ramparts of the castle itself and in the square in the town below.

While Maestlin was able to build or purchase adequate instruments (although not on the scale of Tycho Brahe), he was also blessed with good eyesight. In the records for December 1579, he gives a drawing of the Pleiades with eleven stars down to the sixth magnitude[3]-- a feat that few naked-eye observers can duplicate.

Maestlin was interested in sundials like many of his contemporaries. Zinner lists a manuscript of lectures on sundials in Erlangen,[4] but I have not seen the work. He gave the lectures in 1613. As he made numerous observations of the altitude of the sun at Tübingen and Backnang, he was able to collect data for tables which could be employed with the sundial. In the New York Public Library there is a manuscript attributed to Maestlin entitled Tabula Motus Horarii with a date given of 1586 or 1587. The handwriting seems to be Maestlin's. The tables

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[1] Bohnenberger, Lebensskizze, p. 4.

[2] Kommerell, "Mästlin," p. 93.

[3] Cod. Vindob. 10887, f. 19v.

[4] Zinner, Verzeichnis, p. 218.

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give the daily motion of the sun in hours and minutes with positions given at two-minute intervals. Several other similar tables are given with different intervals, followed by a table "Canon Ascensionum obliquatúm partiúm Ecliptícae conviens latitudim 52° 20'". This table gives the equivalent segments (in degrees, minutes, and seconds) of the ecliptic which correspond to each degree of the celestial equator through the signs of the zodiac. Interestingly, the table is not for any place in Württemberg, for the latitude is too far north. The only cities in Germany that might have come close to this position (using the sixteenth-century estimates of latitude) would be Wolfenbüttel, Braunschweig, or Münster of the better-known towns. Several Dutch cities might also have fit the place. Kassel, for example, where the Landgrave Wilhelm IV had his observatory, is somewhat south of this latitude. There are no annotations or prefatory remarks on the manuscript, so we are left to guess for whom or why the table was drawn up.

Upon hearing of the telescopic discoveries of Galileo and others, Maestlin obtained two small telescopes himself with which he could see the sunspots but little else at first. Writing to Kepler in 1613, he says:

> I have two of those new optical telescopes which are clear enough, but I cannot observe either the satellites of Jupiter or those of Saturn [with them], nor have I been able to obtain a telescope up to now that would show me these apparitions. Much less have I been able to see the horn-like shape of Venus (like the moon) as Simon Mayr has.[1]

Maestlin's telescopes were certainly not as powerful as Galileo's best instrument; he made repeated efforts to observe the phenomena Kepler and Mayr had mentioned but a year later complained to Kepler:

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[1]Letter of 28 April 1613 (O.S.). GW XVII, No. 651, 57:155-59. Mayr's telescopic observations were announced in his Mundus Jovialis (Nürnberg, 1614). Maestlin may have heard of his observations through

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> I grieve, however, not to possess a perfect telescope [perspicillum] of the same kind myself . . . much less to see well all of Jupiter's satellites. So, as yet, I have not been able to see the crescent shape of Venus through either of my telescopes (I have two which are certainly accurate enough otherwise); currently, one might be able to see [Venus] before it sets if the sky were very clear . . . Up to now it has been obstructed by inclement weather.[1]

He had evidently been able to observe the Jovian satellites (which does not require a powerful telescope), but not Venus' phases. There is no further mention by him of telescopic observation, so he must have given up and not attempted to obtain a better instrument. If he observed the moon with his telescopes, an undertaking which would follow from his interest in lunar astronomy, there is no record of or reference to it.

The objects of Maestlin's observational techniques were many and varied: in addition to various planetary aspect observations, solar altitudes, and lunar eclipses that are recorded in the Vienna manuscript, there are also records of the occultation of Venus on 23 May 1587 (O.S.) and the observations of the comets of 1585, 1590, and 1592. The bulk of the remaining observations is of eclipses: Maestlin refers to the lunar eclipses of 8 December 1573, 7 October 1576 (partly obscured by clouds), 2 April 1577, 16 September 1578, 31 January 1580, 7/17 July 1590, 3 October 1595 (N.S.), and 2/12 April 1596. Some details of these observations are lost, but others are preserved in the Fragmenta appended to the Vienna collection. Maestlin also alludes to a solar eclipse of 10/20 July 1591, although no details are given; this eclipse is given as partial for Tübingen by Oppolzer.[2]

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intermediaries or from Mayr himself.

[1] 17 May 1614, O.S; GW XVII, No. 686, 110:28-39.

[2] Oppolzer, Canon of Eclipses (New York: Dover, 1962), No. 6641.

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The Fragmenta includes a number of miscellaneous observations from 1572 to the late 1590's. A number of eclipses are given with both observational details and reductions. The earliest is a lunar eclipse of 25 June 1572 for which Maestlin used the calculations of both the Alfonsine Tables and the Prutenic Tables. For the lunar eclipse of 8 December 1573, he employed tables given by Ptolemy, Peurbach, Alfonso, Schöner, and Bianchini. For the solar eclipse of 13 November 1574 (partial), he used both Peurbach and the Prutenic Tables, while for the lunar eclipse of 7 October 1576 he used Bianchini, Schöner, Peurbach, and the Prutenic Tables. For the majority of eclipse observations after 1576, Maestlin relied primarily upon the Prutenic Tables: the young astronomer must have realized that they were somewhat more accurate than the older compilations. It does not seem likely that his predilection for the Copernican hypothesis was such a great factor in abandoning the older ephemerides and tables but that, rather, the practical application of the older tables showed their inadequacy. Maestlin had published the 1571 edition of Reinhold's work and, in 1580, published his own ephemerides based upon that work.

Observations of solar eclipses were often made by means of Maestlin's camera obscura and quadrant and those of the moon by quadrant and cross-staff. The Fragmenta diagrams show how he observed, and Kepler gives Maestlin's method.[1] His last eclipse observation in the Vienna Fragmenta is of the lunar eclipse of 14/24 April 1595. Beyond that date, eclipse observations are found in the Stuttgart manuscripts which include the solar eclipses of 1581, 1598, 1612, 1613, 1614, and 1621 and the lunar eclipses of 1614, 1616, 1619, 1624, and 1628. He must have made

[1] In his Optics, GW II, 307-8.

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further eclipse observations, but there are no records. The observations in the early years of the seventeenth century were often made along with his son Gottfried or students, for Maestlin was a septuagenarian during his latest observations. He observed practically all the solar eclipses visible in Württemberg during his adult life and most of the lunar eclipses between 1572 and 1580 and from 1612 to 1630. This thirty-year gap suggests that several records have been lost.[1]

In all, Maestlin made observations of at least fifteen lunar eclipses, eight solar eclipses, and several occultations which he mentions in his Epitome Astronomiae.[2] The sun was one of his chief objects of observation, and he made several attempts to find the angular diameter of it by various methods. These methods are described in the Vienna manuscript.

One method was as follows.[3] A small hole was let into the roof. Directly beneath this hole (c,d), Maestlin placed a board and upon it drew two lines (g,l) which were the same distance apart as was the diameter of the hole. Therefore, line g corresponded to one end of the diameter (c), while line l corresponded to the other end (d). The sun's image passed through the hole onto the board. When the left edge of the sun's image touched line g, the clock was started. As the sun moved to the right in the sky, the image moved to the left until the right edge touched line l. The time was noted. The sun had moved through an angle equal to its apparent diameter. One hundred forty-six ticks had elapsed by the clock which was equivalent to about 149 seconds (one tick of his clock

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[1]Oppolzer lists many other lunar eclipses visible in Germany from 1580 to 1612. It is highly unlikely that either the weather interfered with all of them or that Maestlin made no lunar eclipse observations for thirty years.

[2]See below, section 3.3. [3]See Diagram 1, following page 95.

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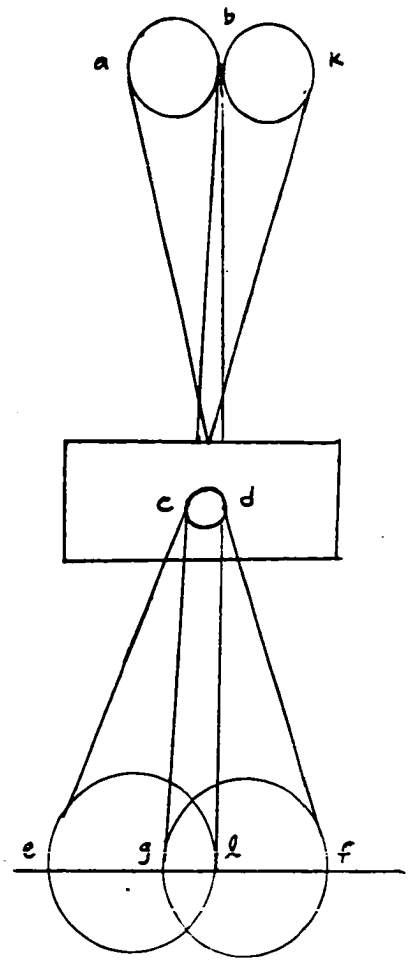

DIAGRAM 1

Method for Measuring the Apparent Diameter of the Sun.

The sun is ab and bk. The hole let in the roof is cd. Line eglf is the line of centres of the sun's image; gl = cd.

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equalled $1^s.02$) which is nearly 37'16". Subtracting a small amount for the hole's diameter, Maestlin arrived at 34'13" as the apparent size of the sun's diameter. This measurement was made on 5 December 1577. On the following day, he arrived at a measurement of 32'6". Repeating the observation on 15 January 1578, he computed a value of 32'3/4". Maestlin's values were moderately close to the modern ones, the range being between 32'36" on 1 January and 31'31" on 1 July.

It is practically impossible to ascertain Maestlin's precision of observation, for we know the limitations of neither his clock nor his instruments. Even if these factors were known, the Oppolzer canon is so inaccurate at times that an estimate of accuracy would still be difficult.

The invention of the telescope allowed astronomers to observe, in detail, the face of the sun for the first time. In 1611, at least four men independently observed the sunspots: Galileo in Italy, Christopher Scheiner and Johann Fabricius in Germany, and Thomas Harriot in England. Scheiner first recorded the sunspots on 21 October, while Galileo first mentioned them on 1 October.[1] Both had made previous unrecorded observations, however. It was Fabricius (1587-1615), son of the astronomer David Fabricius, who was first into print: in the summer of 1611, he published at Wittenberg his De Maculis in Sole Observatis, et Apparente earum cum Sole conversione narratio.[2] Observing with both camera obscura and small telescopes, he decided that it was a sunspot that Vergil had alluded to in his Georgics and that sunspots had been mistaken for transits of Mercury by Averroës, Scaliger, and Kepler (in his Singular

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[1]Stillman Drake, Discoveries and Opinions of Galileo (New York: Doubleday, 1957), p. 82. [Hereinafter cited as Drake, Discoveries.]

[2]Extracted in part in Antonio Favaro, Miscellanea Galileiana inedita (Venice: Antonelli, 1887), pp. 73ff. [Hereinafter cited as Favaro, Miscellanea.]

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Phenomenon).[1] Scheiner (1575-1650) wrote letters to the Augsburg Duumvir Marcus Welser, three of his letters being published in January 1612 under the pseudonym of Apelles. These letters, followed by a supplemental letter soon thereafter, were then forwarded to Galileo by Welser; Galileo responded with three letters which were published as Istoria e dimostrazioni intorno alle macchie solarie in 1613.

Maestlin took no notice of the controversy between Galileo and Scheiner. His interest aroused by the reports of Fabricius, Scheiner, and Kepler, Maestlin undertook to observe the spots for himself. In a letter to Kepler of 28 April 1613 (O.S.), he describes his observations.[2] He employed his telescopes a little after sunrise on 20/30 May 1612. With him were Hafenreffer, Sigwart, Ziegler, and many students, all of whom clearly saw two spots. Kepler had suggested that the sunspots might be clouds, but Maestlin disagreed saying that he thought them to be permanent bodies.[3] Although the telescopes were small and of low power, Maestlin concluded:

> I had almost forgotten: we observed the edge of the sun not to be terminated by a perfectly circular line -- so clearly different by the same method [i.e. camera obscura] as by diverse telescopes. Indeed, we saw, as well, great projections and noticeable chasms, such as the mountains and valleys on earth. Is the body of the sun, therefore, really rough like the earth's globe? Certainly the moon is similar to the earth, as I proved in the disputation.[4]

His observations suggested to him that the sun was like both the earth

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[1]Favaro, Miscellanea, p. 37. Kepler gives details of these observations in his Phaenomenon singulare seu Mercurius in Sole (Leipzig, 1609); GW IV, pp. 81ff.

[2]GW XVII, No. 651, pp. 56-7.

[3]Ibid., p. 56.

[4]Ibid., pp. 56-7:138-144.

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and moon, whose features he had equated in his disputation on the inequalities of motions in 1606.[1] This conclusion was certainly not an orthodox one and placed Maestlin rather close to the plurality-of-worlds view. Kepler, on hearing this report, suggested that Maestlin's optics were faulty, for the sun surely was perfectly spherical.[2] Up to this time, Maestlin had seen both Fabricius' and Scheiner's works on the sunspots but not Galileo's. Kepler described that work to Maestlin who replied that, if Kepler's report were true, it was a pity that Galileo had written in Italian rather than in Latin.[3]

Maestlin mentions the spots again in a letter of July 1613[4] and tells Kepler that he thinks the transit of Mercury in Charlemagne's time and those transits mentioned by Copernicus were, indeed, sunspots. Maestlin's opinion of the nature of sunspots remains ambivalent, but he declares "There are certainly many things in nature about which neither we nor anyone else have ever thought anything."[5]

Maestlin's interest in lunar astronomy was primarily oriented toward eclipse observations. He did, however, make some significant comments on the moon and at least one independent discovery -- the cause of the ashen light. He was not the first to explain the ashen colour of the unlit portion of the visible moon, for Leonardo da Vinci had earlier suggested that the earth's reflected light was the probable cause; however, Leonardo had not published his finding, and when Maestlin offered

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[1]Caspar says in thesis 88f. GW XVII, p. 459n. The work is now lost.

[2]GW XVII, No. 658, p. 64. Letter to Odo Maelcot, 18 July 1613.

[3]Letter of 17/27 May 1614. GW XVII, No. 686, p. 110.

[4]Ibid., No. 660, p. 68.

[5]Ibid., p. 68:82-3.

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the correct explanation in lectures in 1592 and published it four years later, he was, for practical purposes, the discoverer of the true nature of the phenomenon.[1] His conclusion appeared in the Disputatio de Eclipsibus and was reported by Kepler in his Dissertatio cum Nuncio Sidereo of 1610, a comment upon Galileo's telescopic discoveries. Galileo had given the correct interpretation of the ashen light in his Sidereus Nuncius,[2] but Kepler recalled Maestlin's discussion of the phenomenon, particularly since he had included Maestlin's comments in his own Optics six years earlier.[3] Maestlin also mentioned his explanation in his Epitome. Kepler says in his Dissertatio that " . . . the proof that this light is derived from our earth was known to Maestlin 20 or more years ago. I transferred it from his exposition to my 'Optical Part of Astronomy' . . ."[4] In his Optics, Kepler printed in full theses 21 to 23 of Maestlin's disputation with its explanation.[5] In these theses, Maestlin points out that the light is best seen at new moon and wanes thereafter, being nearly invisible at quadrature. Furthermore, the light is best seen at twilight. He then argues that the moon certainly does not have an innate source of light, as some think, but must obtain it from another source. The obvious answer for him was suggested by the alignment of the sun, moon, and earth at which time the ashen light was best

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[1] I have seen no evidence of other correct explanations prior to Maestlin's. See Rosen's comments in Kepler's Conversation with Galileo's Sidereal Messenger (New York: Johnson Reprint, 1965), p. 157n. [Hereinafter cited as Kepler, Conversation.]

[2] Drake, Discoveries, pp. 42ff.

[3] For Kepler's discussion, see GW II, pp. 223f.

[4] Kepler, Conversation, p. 32.

[5] GW II, p. 223:14 - 224:6. Translated by Rosen; Kepler, Conversation, pp. 118-19.

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visible, i.e. close to new moon when the earth could best reflect light back to the moon. That the earth could illuminate the moon in such a manner, Maestlin adds, is manifest, for it lights the earth at night, particularly at full moon when it "virtually changes our nights into days." The mutual reflection of light is suggested by the fact that the ashen light weakens as the moon waxes, while, simultaneously, the night-time sky is brightened steadily by the moon, culminating at syzygy.

Maestlin discusses certain problems of lunar astronomy in another disputation, his Disputatio de multifariis motuum planetarum in coelo apparentibus irregularitatibus, seu regularibus inaequalitatibus, earumque causis astronomicis, which was published in Tübingen in 1606. The book was rare even in the seventeenth century[1] and is now unavailable, the last copy at Stuttgart having been lost during the last war. The disputation took place 21 and 22 February 1606 (N.S.)[2]; and the theses were defended by Maestlin's student Samuel Hafenreffer, son of the theological professor Matthias Hafenreffer. The younger Hafenreffer, writing to Kepler on 4/14 October 1606, said that he had seen the theses which Maestlin had written for his son (presumably Gottfried) and had asked to read them. He was sparked by the theses to defend them in a public disputation, which Maestlin duly granted him, presiding over it himself.[3] Although the work is lost, we are fortunate that Kepler saved a few of the theses in his Dissertatio of 1610.

In this work Kepler first states that Maestlin once saw rain on

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[1]Kepler no longer had a copy in 1627. See GW XVIII, No. 1065, pp. 31ff.

[2]According to Kepler in his Phaenomenon Singulare (GW IV, p. 489).

[3]GW XV. No. 396, p. 354. Hafenreffer had sent Kepler a copy of the work.

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the moon (by naked eye) and quotes from the disputation (thesis 152):

> The moon was eclipsed during the evening of Palm Sunday in the year 1605. On the body of the moon, in the north, a certain blackish spot was seen, darker than all the rest of the body, which looked like red-hot iron. You might have called the spot a cloud, which was spread over a wide area and laden with rain and stormy showers. This kind of formation may be seen not infrequently stretching from the lofty mountain chains to the lower depths of the valleys.[1]

Kepler than hastens to tell Galileo that Maestlin was not mistaking one of the lunar spots, for he had seen a drawing by him which showed that the spot covered 1/4 to 1/5 of the surface and was so black it stood out on the darkened moon.[2] To call this spot a raincloud was bold for those times, even if it was incorrect. Since Maestlin had drawn other conclusions about the kinship of the moon to the earth, his conjecture of rain probably did not seem inconsistent to either him or Kepler. The uneven colouration of the moon at eclipse is not unusual, but this case must have seemed extraordinary to a seasoned observer of eclipses.

Kepler then says that Maestlin deals with the kinship between the moon and earth (thesis 88 and on) "on the basis of their density, shadow, atmosphere, and light borrowed from the sun."[3] He shows that the phases of the moon are also copied by the earth as seen from the moon. In thesis 92, Maestlin takes passages from Averroës (commenting on Aristotle) and shows that the roughness of the moon's surface is like that of the earth.[4] The most interesting conjectures by Maestlin

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[1]Kepler, Conversation, p. 30.

[2]Ibid.

[3]Ibid.

[4]Ibid., p. 114. Rosen says that the Aristotelian passage was misinterpreted by Averroës.

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are those concerning the atmosphere on the moon, which Kepler says are discussed in thesis 145 and on. Kepler also says that in this discussion Maestlin sounded very much like Galileo in the Sidereus Nuncius when Maestlin said:

> Scrutinize the body of the moon closely at any phase whatever. You will observe the outermost edge shining with a much clearer and purer light, and not besprinkled with any spots. In the interior of the body, however, very many darkish blotches are conspicuous everywhere. Who then will say that beneath the uniform light of the former extends nothing but the matter underlying the darker, dappled, and speckled splendor of the latter?[1]

Maestlin surmised from similar observations that the limb was transparent like the air around the earth. One proof of this conjecture was that "the portion that is bathed in sunlight appears to have a larger circumference than the rest of the globe, which is in shadow."[2] He means here that the phenomenon of the new moon's crescent, which appears larger than the darkened portion, is caused by the irradiation of light. He arrived at this conclusion, says Kepler, both from observations at night and in daylight when Venus was occulted by the moon.[3] Kepler also mentions this conjecture in his Somnium, saying that Maestlin, in a note to his thesis 152, said:

> Whether the air [of the moon], like ours, condenses into clouds which, on account of their opacity, take on the appearance of very solid bodies and for that reason look incandescent or fiery, as among us, when the sun rises or sets, I leave undecided. Experience has certainly taught us that the enveloping brightness appears at various times more or less limpid.[4]

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[1]Kepler, Conversation, p. 31.

[2]Ibid.

[3]This may refer to the observation of an occultation of Venus by Maestlin noted in Cod. Vindob. 10887.

[4]Kepler, Somnium, p. 146.

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Kepler then mentions the black spot of 1605. Maestlin, Kepler, and Galileo (who soon withdrew the idea) were not the only contemporaries to think the moon had an atmosphere, for Bruno and Longomontanus agreed with them.[1] Maestlin, like Bruno somewhat earlier, made his conjecture from naked-eye observations before the invention of the telescope. It was, perhaps, from ideas such as these that Maestlin carried his analogy between earth and moon to its logical extreme. Wilhelm Schickard, writing to Kepler on 2/12 March 1620, said that Maestlin, in a public lecture, claimed that the moon was inhabited.[2] To find believers in a form of the plurality-of-worlds view among the literati of the late sixteenth and early seventeenth centuries is not uncommon, but Maestlin's is a revolutionary idea for a university professor of astronomy.

Maestlin may have derived some of his ideas from Plutarch's little work on "the face in the moon."[3] Needless to say, his views on the kinship of the moon to the earth were certainly at variance with the Peripatetic interpretation that the moon was simply aether. His ideas were passed on to Kepler who generally publicized them, although the credit usually has gone entirely to Galileo who, of course, made the decisive telescopic observations.

3.2 Maestlin on the New Star and Comets

The nova of 1572 marked a turning point in astronomy, for Tycho Brahe convinced himself that its appearance showed the basic Aristotelian assumptions about the nature of the supra-lunar world to be false.

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[1] Thorndike, History of Magic, VII, p. 638.

[2] GW XVII, No. 872, p. 426.

[3] Kepler had translated Plutarch's work, which influenced his ideas in the Somnium.

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The same nova also offered Maestlin his first major astronomical event to observe and describe. The new star flared up probably in late October of 1572.[1] Maestlin saw it during the first week of November, being one of the first German astronomers to do so.[2] He described his observations and deductions concerning the new star in a very short tract entitled Demonstratio Astronomica Loci Stellae Novae, Tum Respectu Centri Mundi, Tum respectu Signiferi & Aequinoctialis, dated 6 March 1573. The Demonstratio was first printed in Nicodemus Frischlin's Consideratio Novae Stellae (Tübingen, 1573): the work was better known through its publication in Tycho's posthumous Progymnasmata of 1602.[3] Tycho says that he printed the entire tract as it was not long.[4]

Hellman[5] lists another work by Maestlin on the nova entitled Beobachtungen des neuen Sterns in der Cassiopea dated 1573; however, this work is not listed by either Houzeau-Lancaster or Zinner. The title is

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[1]Elias Camerarius claimed to have seen it on 1 October; German rustics are said to have observed it early that month and Paul Fabricius said it appeared about the end of the month; Muñoz said that Spanish shepherds sighted it on 2 November; Wolfgang Schuler saw the star four days later, and Maestlin observed it that week as well. By the eighth, Thurneisser, Maurolyco, and Chyträus had noted it, followed by Cornelius Gemma on the following day. Tycho did not observe it until the eleventh. See: Tycho, Op. Om. II, pp. 452-3; J. L. E. Dreyer, Tycho Brahe, A Picture of Scientific Life and Work in the Sixteenth Century (New York: Dover, 1963), pp. 60f. [Hereinafter cited as Dreyer, Tycho Brahe].

[2]Tycho Brahe, Astronomiae Instauratae Progymnasmata (Prague, 1602), p. 548. [Hereinafter cited as Tycho, Progymnasmata].

[3]Ibid., pp. 544-548; Tycho, Op. Om. III, pp. 58-62. Tycho may have extracted Maestlin's tract from Frischlin's work. He says (p. 544) that Maestlin was "at that time in the church in the town of Backnang." As he was actually at Tübingen at the time, his residence must have been inferred from his work on the comet of 1577.

[4]Ibid., p. 544.

[5]Hellman, Comet of 1577, p. 142. Also given in Sister Suzanne Kelly, The De Mundo of William Gilbert (Amsterdam, Hertzberger, 1965), p.111.

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found in Jöcher,[1] but he also mentions a Beobachtungen des merkwürdigen Cometen; 1577 und 1578 which did not exist. I surmise that both are simply Jöcher's paraphrases of the Latin titles, and, as I have found no evidence that a German tract on the new star by Maestlin existed, I would judge the German title to be a bibliographical ghost.

Tycho tells us that Maestlin possessed no instruments when the nova appeared "inasmuch as he was quite destitute at that time."[2] Maestlin observed the nova by means of a thread held before his eyes to discover whether the nova had a parallax or moved with respect to neighbouring stars. This observational method was both simple and ingenious:[3] he located four stars (two in Cassiopeia near the nova, one in Cepheus, and one in Ursa Major) which were so aligned that when the thread was held before the observer, the star in Ursa Major, the nova, and a star in Cassiopeia were in line. At right angles to this line another line was found which contained the star in Cepheus, the nova, and the other star in Cassiopeia. The nova fell at the intersection of the two lines. By observing through the night and over several nights, he could see whether the nova changed its position relative to his four stars. He could detect no motion and concluded that the new star was stationary and had no parallax.

Tycho, in his De Mundi recentioribus phaenomenis of 1588, discusses Maestlin's use of the thread.[4] He feels that the method can lead to

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[1]C. G. Jöcher, Allgemeinen Gelehrten-Lexikon Ergänzungsband (Hildesheim: Georg Olm, 1961), IV, p. 1894.

[2]Tycho, Progymnasmata, p. 543.

[3]This method was used by Geoffrey of Meaux as early as 1377. See Hellman, Comet of 1577, p. 58.

[4]Tycho, Op. Om., IV, pp. 213-4.

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errors for several reasons: the observer can hold the thread steady only with difficulty, much less be certain that all three objects are exactly in line. Being certain that the thread passes through the exact centres of the objects is also difficult, due to the scintillation of stars. Furthermore, the observer cannot be sure his transversals are at exact right angles; often, there are not stars whose positions are known near enough to the object so that right-angled lines cannot be drawn. Tycho says that he used a thread in his youth, but found a straight-edge was better. Maestlin's chief error, he thinks, is not so much his technique than his reliance upon Copernicus' star positions, which differ from Tycho's by about 1° on the average.

In the case of the non-moving nova, Maestlin's observational accuracy can be questioned. His error could not exceed about 1° to locate the star above the moon. To place the nova among the stars, his accuracy would have to have been much greater. If his technique were well refined (as Tycho assumed), then repeated observations of the nova might have decreased his error. Whether his error was minimal or not, it is impossible to say. In any case, his conclusion that the new star was beyond the planets was correct.

From his observations of the change in brightness and colour of the star between early November and December, Maestlin concluded that Aristotle's view of a changeless region above the sphere of the moon was false.[1] That the nova had no parallax indicated that it was above the moon; the lack of motion suggested to him that the nova was no ordinary comet.[2] Not only was the new star above the moon, it was beyond the

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[1]Tycho, Progymnasmata, pp. 544-5.

[2]Digges and Dee had suggested the star was retreating on a line. The idea of a "stationary comet" could have also been invoked.

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planets or, more precisely, in the sphere of the fixed stars:

> Truly we have concluded from accurate observations that this tremendous star is not merely meteorological, nor a planet, but in fact should be numbered among those in the eighth sphere or starry firmament.[1]

As Copernicus had shown, the further a planet is from the sun, the slower it moves. The new star moved with the same speed as the fixed stars (or rather did not move at all) and was, therefore, in the same sphere. This argument is the first use by Maestlin of Copernicus' theory.

Maestlin[2] then gave a position for the new star by employing the four stars earlier located. From the positions of the known stars taken from Copernicus' catalogue, he was able to give the nova's position by using spherical trigonometry drawn from (as he tells us) Regiomontanus and Theodosius. From his calculations, he obtained a longitude of 6° 50' of Taurus and a latitude of 54° 0' north. Tycho[3] calculates from his own data using Maestlin's choice of stars and obtains a longitude of 7° 3' of Taurus and a latitude of 53° 39' north. The discrepancy arises since Tycho had new positions of certain stars obtained by observation, while Maestlin relied upon the (inaccurate) positions given by Copernicus.[4]

Maestlin did not give any astrological significance for the new star which accounts, in part, for the brevity of the tract. He says:

> What this new star truly portends, we leave for others to dispute; it is satisfying enough for those of us astronomers who love the truth to describe it and write about it.[5]

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[1]Tycho, Progymnasmata, p. 545.

[2]Ibid., pp. 546-7.

[3]Ibid., pp. 550ff.

[4]The Progymnasmata was written long after 1572.

[5]Tycho, Progymnasmata, p. 548.

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But he still faced the problem of the nature of the phenomenon he was observing. Since Aristotle was clearly in error, the nova must represent something that could not be described in the usual way. Rather than invent an explanation, he concluded that the nova is "hyperphysical," that is to say a miraculous creation of God.[1]

Maestlin and Tycho were not the only astronomers to find a supra-lunar place for the new star, however, for Tycho also lists the Landgrave Wilhelm IV, Thaddaeus Hagecius, Paul Fabricius, Bartholemew Reisacher, Paul Hainzel, Cornelius Gemma, Hieronymous Muñoz, and Franciscus Vallesius in the same company. But, like Tycho, Maestlin saw the appearance of the nova as a blow against Peripatetic philosophy.

As important as the new star was for the development of Maestlin's views on astronomy, the comet of 1577 was even more so. The nova was a new type of object for the sixteenth-century astronomers; since Aristotle had no explanation for a phenomenon such as this, it was easier for men to accept the appearance as a supernatural object placed in the heavens by God, or to appeal to ideas such as "stationary comets." Although both Tycho and Maestlin saw the difficulties produced for the Aristotelian celestial physics by the new star, these difficulties were not necessarily drawn by the many astronomers who decided the new star was supra-lunar. The comet of 1577 was different, however, for comets were well-known; Aristotle and his Peripatetic successors had systematic explanations for such objects--they were atmospheric or, at least, sub-lunar.[2]

The appearance of the comet of 1577 offered an opportunity for

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[1]Tycho, Progymnasmata, p. 548.

[2]See particularly Hellman, Comet of 1577, chapter 1.

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excellent observers of the time, and Maestlin and Tycho took full advantage of it. Maestlin's work on the comet is his most important book for reasons detailed below. The full title of this work was Observatio & Demonstratio Cometae Aetherei, Qui Anno 1577. Et 1578. Constitutus in Sphaera Veneris, Apparuit, Cum Admirandis eius passionibus, varietate scilicet motus, loco, orbe, distantia à terrae centro, &c. adhibitis demonstrationibus Geometricis & calculo Arithmetico, eiusmodi de alio quoquam Cometa nunquam visa est., which was published in Tübingen by his publisher Georg Gruppenbach in 1578.

He dedicated the work to Duke Ludwig of Württemberg, his patron who had recently assigned him to the deaconry at Backnang. The dedication is in suitably purple prose: he lauds the great rulers (especially patrons of science like King Alfonso), the great astronomers, and, of course the duke for his patronage. As he stated in his tract on the new star, he would not conjecture any of the astrological portents of the comet, for he had always "leaned toward astronomy rather than astrology;" he left such predictions to others.

Chapter one of his work is a general survey of the comet. He describes its shape to be like fasces; its colour was white and its coma, or cauda (he uses both terms interchangeably) was directed away from the sun. The tail, which was sunlight dispersed by the comet's body, extended over nearly 30° which was unheard of for a comet.[1] He first observed the comet on 12 November 1577 and last saw it on 6 January 1578. The second chapter deals with the first appearance of the comet. Although he had first seen it on the 12th, the weather had been poor, and it might

[1]Tycho had found the tail to be 22° long on 13 November. Maestlin notes that the comet of 1531 had a tail 20° long.

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have appeared as early as the 5th. Its disappearance probably took place around 10 January, but poor weather conditions obscured his view.

The third chapter is more important and breaks with the accepted notions of the time. Maestlin decided that the comet was supra-lunar. He argued that, since the planets (the motions of which are employed by the astrologers for their purposes) are in the heavens and follow natural laws, comets, which are likewise used by astrologers, must be assumed to follow natural laws, too; therefore, comets must be in the heavens. To show the comet to be in the aetherial region Maestlin had to show that the comet lacked a parallax. Therefore, he gave an explanation of parallax and the use of this effect by Regiomontanus for estimating distances. After he made accurate observations, he says, he could find no parallax and thus concluded that Regiomontanus' method would not apply.

By observing with his thread[1] at two well-separated times during the evening, he could determine the distance of the comet from a selected star. By observing the comet the following night, he could find the motion of the comet along its path; with this value, he could find how far the comet would move between his two observations the night before. Comparing the calculated motion with the distances of the comet from the selected star, he could see if a residual motion was present: this would be the parallax. If the comet were closer to the earth than the planets, a parallactic displacement would be visible when the comet were closer to the horizon.[2] An observation of the comet was made by Maestlin on

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[1]He had other instruments but did not rely upon their accuracy.

[2]A line drawn from the centre of the earth to the comet would coincide with a line drawn from the observer only when the comet was at the zenith. When the comet was near the horizon, the angular distance between the two lines of sight would differ the most. Another method of ascertaining

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2 December at 6 P.M. and again at 9 P.M., with respect to stars in the constellation Equuleus. He repeated his observation the following evening and found the daily motion of the comet from which he could calculate the position it should have had at 9 P.M. on the 2nd. He found no parallax whatsoever and concluded that the comet was supra-lunar.

There are three major sources of error in these observations. The first is the same as for his nova observations: instrumental. Second, a comet is not so clearly defined as a star and locating the exact nucleus every time would not be very likely. Third, as Tycho pointed out in his 1588 work on the comet, Maestlin had relied upon the star positions given by Copernicus. Therefore, the cometary positions from day-to-day were inaccurate.[1] The combination of these errors militated against a firm conclusion that the comet lacked a discernible parallax.

Chapter four concerns observations by others that showed the comet to be sub-lunar. Of the great number of observers of the comet of 1577, only Maestlin, Tycho, Röslin, Landgrave Wilhelm IV, and Cornelius Gemma found the comet to be supra-lunar. Tycho had written only a German tract (which Maestlin had not seen) on the comet,[2] nor had he received Gemma's[3] or Röslin's[4] works. The Landgrave did not publish a work on

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parallax was to have observations from two known geographic locations made simultaneously. For this method, one had to trust his counterpart's observational care and instrumental accuracy. See Diagram 2, following p. 111.

[1]A table of the stars employed is given by Tycho: Op. Om. IV, pp.217-8.

[2]In Tycho, Op. Om. IV, pp. 381-96 with a title De Cometa Anni 1577 supplied by Dreyer.

[3]De Prodigiosa Specie, Naturaq. Cometae. . . (Antwerp, 1578). See Hellman, Comet of 1577, pp. 177-183.

[4]Theoria Nova Coelestium METEΩPΩN. . . (Strasbourg, 1578). See Hellman, Comet of 1577, pp. 159-174.

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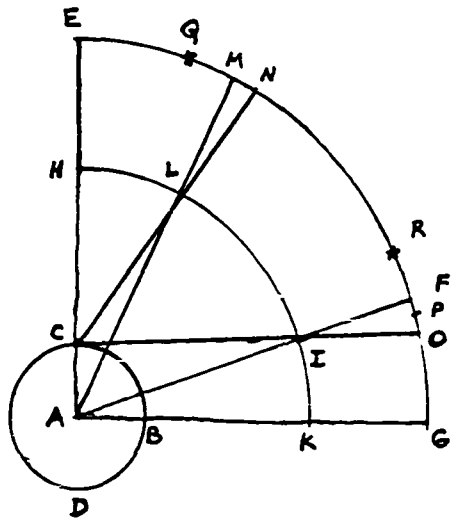

DIAGRAM 2

Parallax of Comets

CBD is a great circle of the earth, centre at A. EFG is the sphere of fixed stars, HK the sphere of the comet. L and I are two positions of the comet (for Maestlin, at 6 and 9 p.m.); M and F are the true places and N and O the apparent places of the comet. Q is the selected star, R its position three hours later. If arc FP equals arc MN, PO is the parallactic difference.

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the comet, but his observations were included later in Tycho's De Mundi Aetherei Recentioribus Phaenomenis as were those of the others listed above. Thus, all the treatises in Maestlin's hands were by those who believed the comet to be sub-lunar.

Many of the tracts he saw simply used Aristotle as an authority and no more, but the others who employed observations and geometrical demonstrations displeased him, for he had every faith in the care and accuracy of his methods. Still, he was aware that to break from Aristotle's opinions was not a simple matter:

> I confess, however, that if I had not discovered the comet to be in the aetherial region by personal, certain, repeated, and most diligent observations, I would by no means have been easily persuaded [of it]. This I discovered, thus, by many experiments, because in this sort of great divine work neither the considerations of authority nor the opinions of men can be accepted in place of the rule of truth.[1]

Had he still entertained doubts after 1572 whether or not Aristotle was correct, he was convinced in 1576 that the Peripatetic philosophy could not account for all that occurred in the heavens. Once again, his personal view of astronomy as a science demonstrated by mathematics stands out in sharp contrast to many of his contemporaries' views.

One example that Maestlin gives is of a certain disciple of Reinhold (Tycho[2] identifies him as Nicolaus Winckler) who, in his book,[3] shows that the comet is sub-lunar, for it moves imperfectly through the sky (an argument of Aristotle). Maestlin suggests that if one followed the Stagirite in his opinion that the slower the motion of a body in the sky,

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[1]Maestlin, Observatio & Demonstratio, p. 11.

[2]Tycho, Op. Om. IV, p. 213.

[3]Cometa Pogonias Qui Anno Labente 1577. . . (Nürnberg, 1578). See Tycho, Op. Om. IV, pp. 348ff.

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the further it lay from the earth, then the comet would definitely be supra-lunar. Winckler observed the comet on 6 December at 5 P.M. and found that it was elevated 46° while a star in Aquila, then on the meridian with the comet, stood at 36°. Finding the latitude of the star to be 29° 10' from the Tabulae Prutenicae, Winckler reasoned that this should be added to the 10° difference in meridian altitudes, giving 39° 10'. Subtracting this figure from the comet's altitude, he obtained a "parallax" of 6° 50' which gave a distance from the centre of the earth of 6,872 German miles and a few paces. Maestlin objects to this spurious mathematical procedure and notes that the star in Aquila was in fact on the meridian a little before 2 P.M., not 5 P.M. From such calculations, he suspected that Winckler had lifted the example from Hagecius' Dialexis on the nova of 1572.

Maestlin then turns to the observations of Andreas Noltius.[1] Noltius had observed the comet on 7 December (with a quadrant) at one hour intervals. Employing Regiomontanus' method, he found parallaxes of 4° 59' and 5° 32'; from the mean he calculated that the comet was 8 2/3 earth radii distant (7,727 German miles). Maestlin compared his own observations made that night at 6 and 9 P.M. and found there to be no discernible parallax. Noltius' observations were clearly inaccurate, possibly, thought Maestlin, due to the fact that the comet was at such an altitude that an error in observing would be greatly magnified in the calculations.

Maestlin then reviews Aristotle's opinions on comets, commenting on the philosopher's view of the place of comets:

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[1]Noltius' work Observatio, Und Beschreibung des Cometen...des 77 (Erfurt. 1578), is described by Tycho, Op. Om. IV, pp. 337ff.

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> Aristotle was the greatest philosopher to have looked into it but he does not make mention, in his words, of aetherial comets other than to refute by name the ancient philosophers, but rather he fixes the place of comets as the airy (or if higher, the fiery) region. I have no answer for this than that Aristotle was unwilling to put into his writings something concerning [aetherial comets] since perhaps none had appeared in his time (although a way for investigating parallaxes was unknown as yet, being reserved, as it happens, for our own age) but all were in the airy region, as were those which were observed in the years 1475 and 1532 and others, too. But even Aristotle himself bears witness to how one may reason poorly from one or another single instance to the universal.[1]

He thinks that Aristotle should have seen that if cometary properties such as motion, colour, magnitude, etc. can differ greatly, so too could cometary locations. As far as what the material of comets might comprise, he has no idea. Having removed comets from the sub-lunar regions where comets could be thought of as hot and dry exhalations or fiery sparks, he was left with only aether as a possible material. The truth, he believes, is known only to God.

Maestlin knew of only two examples of unusual supra-lunar objects, the new star seen in 1572 and a comet reported by Albumasar:

> Albumasar, who flourished about the year 844, relates that in his time a comet was seen above the sphere of Venus. What is to be supposed that the physical cause of this might have been, if the place of comets is taken to be none other than the elementary region, or its material as anything other than an exhalation?[2]

Maestlin did not feel that all comets were supra-lunar but that some may conform to Aristotle's theory (e.g. the comets of 1475 and 1532). He

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[1] Maestlin, Observatio & Demonstratio, pp. 16-17.

[2] Ibid., p. 19. Tycho had also noted Albumasar's observation. W. Hartner suggests ["Tycho Brahe et Albumasar," in Oriens-Occidens (Hildesheim: Georg Olm, 1968), pp. 502f.] that Tycho found this information in Cardano's Hieronymi Cardani Libelli V (Nürnberg, 1547). In the 23rd section of the 2nd segment, Cardano says: "Dixit Albumasar, Cometes supra Venerem visus est: non igitur in regione est elementari, contra philosophum. . ." Maestlin, who knew Cardano's works, may have consulted the same passage.

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must have suspected that many supra-lunar objects had existed before his own time, having been misinterpreted for want of precise observations. The tracts of his contemporaries on the comet of 1577 must have shown him how little careful work had been done.

In chapter five, Maestlin discusses methods of observing the comet and calculating its positions. While he offers a list of typical astronomical instruments of the time, he says the large ones are too expensive and the smaller ones not sufficiently accurate. For his own purposes, he has employed a great quadrant which he constructed.[1] Employing other instruments was out of the question for "the truth and certitude of the others was doubtful." Instead, he used his thread, although he admits that a straight-edge might be more accurate, as Gemma Frisius had recommended in his book on the astronomical radius.[2] Following this discussion are two problems in spherical trigonometry as examples of his method.

Chapter six gives a summary of his observations of the comet and his description of its apparent path. He gives his daily observations[3] of the comet and its plotted path (for 12 November to 8 January), which he says began at about 3° or 4° of Capricorn and ended at 13° of Gemini, from a latitude of 7° north to 29° north. From his observations he concludes: "The motion was not uniform (as far as appearance) but quite dis-

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[1]Koestler, in the Sleepwalkers (p. 292) remarks that "Maestlin in Tübingen who, though one of the leading astronomers of the time, seems to have possessed no instruments whatsoever. . ." Not only did he have instruments, but he was not in Tübingen nor was he a leading astronomer at the time.

[2]Gemma's suggestion had been followed by Thomas Digges in England for the new star. See Tycho, Progymnasmata, pp. 673ff.

[3]Some values are interpolated because weather hindered observation.

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ordered; although, as it follows, it was most regular in itself."[1] What he means is that although the comet did not seem to move with uniform speed, its true orbit, after being mathematically deduced from the daily motions, could be shown to be quite regular. This demonstration is reserved for the following chapter.

Chapter seven is the heart of the work. Maestlin gives a table of the oblique parts of the comet's path (in 90 divisions) with respect to the ecliptic, beginning at the intersection of the path with the ecliptic (the ascending node), which he states is at 21° 0' of Sagittarius. By spherical trigonometry he finds that the path was inclined 28° 58' to the ecliptic.[2] With his observations, he computes the longitudes and latitudes of the comet for each day from 5 November 1577 to 10 January 1578. Armed with these values, he attempted to find an orbit which would take these factors into account. He says he found a good approximation in the Copernican sphere of Venus as set out in De Revolutionibus, Book VI, chapter 2.(3) Copernicus gave Venus motions of libration to account for its motions in latitude and Maestlin saw that this might account for the seemingly irregular motion of the comet.

It is possible to elucidate his thinking somewhat. If the values given in the tables in Chapter eight are scrutinized, some of his reasons for choosing the sphere of Venus become apparent. Copernicus had placed Venus' apogee at 16° 40' of Gemini; the line of apsides would thus pass

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[1]Maestlin, Observatio & Demonstratio, p. 34.

[2]Tycho had placed the node at 20° 55' of Sagittarius and inclination of the path as 29° 15'. He was pleased that Maestlin had arrived at values close to his own but was sceptical of the use of the thread and the reliance upon Copernican star positions.

[3]This is a discussion of the problems of latitude motion.

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through 16° 40' of Sagittarius, a little over 4° from the comet's ascending node. If the longitudes of the comet are compared with those of the mean sun, the divergence is greatest (i.e. greatest eastern elongation) at the end of the first week of December, when it equals a little over 57° (which is only 9° greater than Copernicus' value for the greatest elongation of Venus).

If the path of the comet with respect to the ecliptic is plotted on a chart, the idea of a circular orbit emerges.[1] The varying apparent speed of the comet suggests the combination of the earth's and comet's orbital speeds in the opposite directions. At this point, Maestlin still could have accepted a geocentric theory for the comet: its varying speed with respect to the mean sun could be accounted for by placing the comet on an epicycle. But the latitudes still were troublesome, and he saw Copernicus' libration motion as a reasonable option.[2]

All these factors can be neatly accounted for by the Copernican theory. However, as Tycho showed, a geocentric or hybrid geocentric system could be applied. Maestlin gives his exposition as if he were still unsure of which system to adopt. He says the decision to adopt Copernicanism was not simple: "Quite unwillingly did I depart from the accepted [i.e. Ptolemaic] opinion concerning the distribution of the spheres of the world."[3] However, he says, geometrical demonstrations are the only proper way to ascertain the comet's orbit, and Copernicus offered the necessary corresponding mathematical arrangement.

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[1]See Diagram 3, following page 117.

[2]Tycho would have nothing to do with libration motions and thought them a blemish on Maestlin's theory. See Tycho, Op. Om., IV, pp. 222f.

[3]Maestlin, Observatio & Demonstratio, p. 38.

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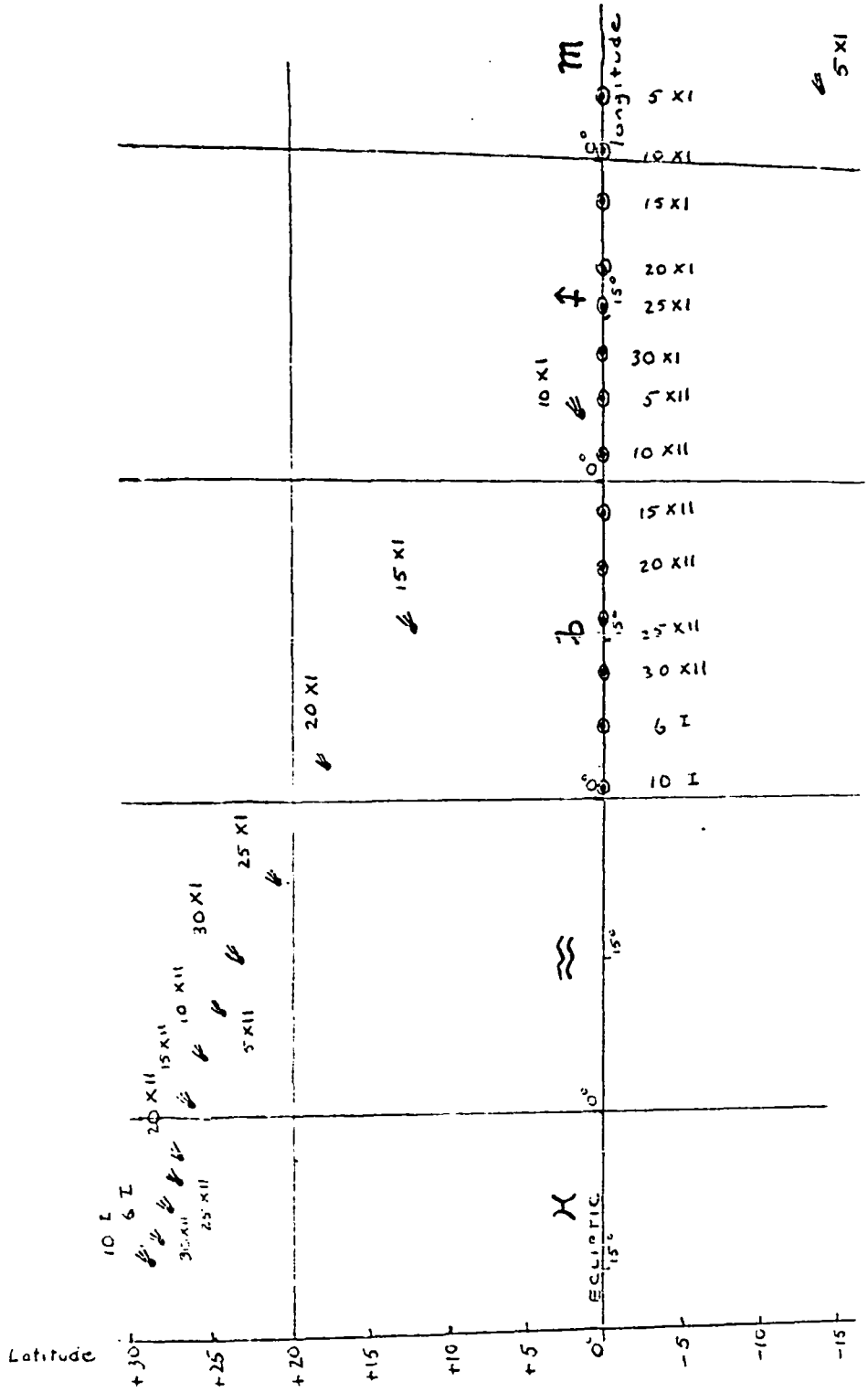

DIAGRAM 3

The Motion of the Comet of 1577

The positions of the mean sun and the comet are given in 5-day intervals from 5 November 1577 to 10 January 1578. The latitudes and longitudes are drawn from Chapter 9 of the Observatio & Demonstratio. The ecliptic is divided into signs of 30° each.

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What may be closer to the truth is that he already was very favourable to Copernicus' theory and the comet offered him an excellent opportunity to test the heliocentric hypothesis. That Copernicus' planetary theory could be employed for comets' motions must have been satisfying, enough so for him to publicly announce his adherence to Copernicanism. Kepler later accepted this conclusion as a proof that the heliocentric theory was correct.[1] Maestlin's conclusion is the first example of the interrelating of cometary and planetary theory.

After stating that he had opted for Copernicus, he gave a short description of the major tenets of heliocentric astronomy and explained the motions of libration in the sphere of Venus. The motion of Venus nearly coincided with that of the comet, he says.

Chapter eight gives a demonstration of the comet's motion, its equalities and apparent inequalities, and the distance of the comet from the centre of the earth. Maestlin explains how the comet moved with respect to the mean sun (employing Copernican terminology) and gives a table of the distances from the mean sun on the dates of observation. From his data, he finds that the comet moved rapidly with respect to the mean sun in November and then slowed in its course. There follows a table of the mean commutation of the comet's orbit (the average longitudinal motion). Giving three diagrams, he shows how the comet moved with respect to the centre of the earth's orbit, and to the mean and true suns. The comet rides on an epicycle inclined 90° to the plane of the deferent (being like Copernicus' libration motion). The comet moved in the opposite direction of the earth.[2]

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[1]See below, section 4.1.

[2]See Technical Appendix (Appendix C).

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The mean distance of the comet from the sun is 0.8420 (where the mean distance of the earth from the sun is 1.000); this figure is obtained in the same way that Copernicus found the relative distances of Mercury and Venus. When one of the inferior planets is at greatest elongation, it forms a right triangle with the sun and earth at the other two vertices--the sine of the angle of elongation gives the relative distance. If the mean distance of the comet's orbit is 0.8420, the greatest elongation is 57° 21'. This makes the comet's orbit slightly larger than that of Venus, whose distance (according to Copernicus) is 0.7193. Once the relative distance to the comet's orbit from the sun is known, it can be converted into earth radii or miles,[1] and the distance, in those terms, from the earth can be calculated easily. On 5 November 1577, the comet was 155 earth radii distant; by 10 January 1578, the distance had increased to 1495 earth radii. Only with the Copernican theory could Maestlin attempt to calculate the distance of the comet (it having no discernible parallax); Ptolemaic astronomy could not give the true order of the planets, much less the distances.

The ninth chapter is a summary and clarification of problems encountered in chapters two and six. Maestlin re-examines his observations to see whether turbid air had spoiled his figures. According to him, the comet ignited (an Aristotelian-inspired explanation) at 4 A.M. on 5 November 1577. As bad weather had intervened in January of 1578, he could not himself say when the comet disappeared but relied upon the observations of Johann Praetorius at Altdorf that the comet was extinct probably on 10 Jan-

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[1]He accepts Copernicus' value of the astronomical unit; the radius of the earth he gives as 860 German miles (as does Tycho).

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uary when Praetorius found that "nothing, not even a shadow was left to be seen."[1] The comet had lasted 66 days, 12 hours, or 118° in its own circle. In the zodiac (i.e. with respect to the ecliptic), it had run through 113° from 20° of Scorpius to 13° of Pisces. To summarize his calculations, he gives a table with a daily record of the place of the mean sun, the distance of the comet from the mean sun, the motion of the comet in is own circle, the longitudes and latitudes of the comet, and the distances from it to the earth's centre in earth radii. Each value was for 6 P.M. excepting the first (ignition) which was for 4 A.M. on 5 November.

He reiterates his use of Copernicus and defends himself:

> The information concerning this admirable comet and the demonstrated motion of it I produced not from hypotheses which have been in use for a long time and employed by habit, but, as I said before, from Copernicus' opinions, not because I am deceived or fascinated by the love of novelty, which I cannot approve, but better: because I yielded to it, compelled by extreme necessity.[2]

Geometrical demonstrations must ultimately be the test for an astronomer when he judges a hypothesis. In this case, he thinks, Copernican astronomy can be admirably employed.[3] Tradition had its place for him but, he adds, "Now Socrates is my friend, and Plato is my friend as well, but the

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[1]Maestlin, Observatio & Demonstratio, p. 50. Tycho observed the comet two weeks later.

[2]Ibid., p. 54.

[3]Copernicus probably did not observe comets. There is some circumstantial evidence that he may have observed the comet of 1533. See: C.D. Hellman in Actes du XI^e Congres d'Histoire de Science, I (1968), pp. 66-70. The only printed reference of Copernicus to comets occurs in the De Revolutionibus, where he says that the Greeks thought the upper regions of the air followed the celestial motions since it was in that region that comets, or Pogoniae appeared. [De Revolutionibus (1543), p. 6.]

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greatest friend is the truth."[1] This chapter closes with praises to God for sending such a spectacle to show His power and glory.

The last chapter is on the signification of the comet (although Maestlin had disclaimed astrology in the dedication). It is evident from the chapter that he had little taste for astrological prediction but felt it to be expected of him. He had no sympathy for the extreme types of astrologers, so he sought a mean between them. He did not think that astrologers bothered to discern the true motions of a comet before they published their predictions. As an astronomer, it was up to him to do so. Although the majority of astrologers had placed the comet under the influence of Saturn, he had found it actually to be in Venus' sphere and, therefore, under Venus' influence. If anything could be drawn from the comet by way of signification, he felt that it would be trouble, probably from the Turks (not a difficult prediction in those days). Indeed, there had been seen a halo about the moon in Backnang on 22 and 23 November, while similar events had been seen from Berlin by Leonhard Thurneisser on 25 November and by Noltius on 19 December, all of which portended war. He dutifully found four historical examples going back to Julius Caesar to show that this would be the probable course of events and then, as if with relief, he suggests that the reader trust in God.

Maestlin's Observatio & Demonstratio is an important work for several reasons. In it, he declares that the comet of 1577 was a celestial object--he was in the company of only four others who so believed--and

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[1]Maestlin, Observatio & Demonstratio, p. 50. This is a form of a saying of Aristotle (Nichomachean Ethics, I.6) popular in the middle ages.

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more importantly, that a comet had a definable orbit like that of a planet. He was the first ever to offer an orbit for a comet and is, in a sense, the father of modern cometary theory.[1] The work announces that its author was a Copernican, not by dogma, but by observation and geometrical demonstration. Although his accuracy can be questioned, his conclusions are a great step forward in cometary astronomy. The spirit of the book is thoroughly scientific.

Just two years later, another comet appeared over Germany and prompted another treatise from Maestlin. His work on the comet of 1580, the Consideratio & Observatio Cometae Aetherei Astronomica[2] was published by Mylius at Heidelberg in 1581. It was not so elaborate or comprehensive as his earlier cometary work. The comet of 1580 was more portentous than that of 1577 for many, since it had been preceded and followed by several atmospheric phenomena which Maestlin called (after Aristotle) "chasms." Once again he dedicated the work to Duke Ludwig of Wirttemberg. The dedication suggests that the phenomena seen in 1580 and 1581 were portents of trouble, and this offered him a platform to call men back to true religion. Although the comet and the atmospheric phenomena offered fertile soil for astrology, he decided to refrain from making a prediction:

> . . .some [of the commentators] draw upon the precepts according to astrologers, since, no doubt, they are able to define the comet according to physical causes. Others examine it astronomically due to the magnitude of the prodigy; I myself propose likewise to simply show the motion, place, and other properties which I can concerning the recent comet, since

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[1]Tycho also found an orbit for the comet but his theory was not published until 1588. Röslin thought all comets might have a common sphere.

[2]For full title, see Appendix B, Item 7. [Hereinafter cited as Maestlin, Consideratio & Observatio.]

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> it is bound by astronomical laws. For this I am better able to show the glory of God.[1]

He then thanks his new patron, the Palatine Count Ludwig, for his post at the University of Heidelberg and gives thanks that the "sacrosanct" religion has been restored in Heidelberg, referring to the purge of Calvinists just prior to his arrival.

The first chapter of the work deals entirely with the terrible chasmata.[2] These Maestlin sees as a God-given sign for man to reform himself, having fallen into impiety, injustice, etc., to say nothing of the present "antichrist" on the throne of St. Peter. The first of these phenomena he saw in Backnang on 5 March 1580 at 7 P.M. Although the sky was clear, the chasms appeared in the north and completely blocked out the stars even though those stars throughout the rest of the sky remained visible. Chasms were seen again on 6 April and 9 April. The chasms appeared to be holes in the sky--white, red, or purple in colour--and some seemed to have spikes or flames. Maestlin also mentions coloured arcs about the sun seen from Göppingen on 24 and 25 July and other daytime phenomena seen on 16 February 1581. These latter sound like mock suns, sundogs, and similar phenomena. The chasms were described by Aristotle[3] as exhalations in the upper air that take fire and are normally blood-red in colour, since it is the only colour that contrasts well with the black of the sky, although purple chasms are sometimes seen. The chasms are akin to meteors for Aristotle. Maestlin's description of the chasms seen in Germany is very similar to Aristotle's account (which

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[1]Maestlin, Consideratio & Observatio, dedication, A3 v.

[2]Cornelius Gemma, in his Prodigiosa Specie (1578) gives a commentary on chasms seen in 1575.

[3]Aristotle, Meteorologica. I.5.

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he had probably read). From Maestlin's description of the chasms, I would think that the aurora was the phenomenon he observed, for a large display takes on such an appearance. Aristotle's short discussion of chasms also suggests aurora, as Lee[1] and Heath[2] have noted. The chasms were normally considered portentous at the time, filling men with terror. A contemporary of Maestlin's, Thomas Hill of England, mentioned that chasms "pronounceth drye tempestes to follow," and quoted Pliny: "be foreshewers of mightie perils. . .as be battels, seditions, and infinite like calamities."[3] If Maestlin also feared these events, he doesn't mention it.

In the second chapter, he turns to the "present comet"[4] and its place, motion, light, head, etc. He was not certain when the comet first appeared, but he saw it first on 2 October 1580. It moved with respect to the ecliptic through five zodiacal divisions--Aries, Pisces, Aquarius, Capricorn, and Sagittarius--that is, moving in retrograde. The comet had no visible coma on 2 October; the comet was globular in shape and dull white in colour, though quite bright. When the coma did appear, it was directed away from the sun as in all comets but was not, he says, diametrically opposite the sun.

He turns in chapter three to observations he made of its motion and apparent place from day to day. He notes that he had relied on

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[1]H. D. P. Lee (trans.), Meteorologica (London: William Heinemann, 1962), pp. 34-5.

[2]T. L. Heath, Aristarchus of Samos (Oxford: Clarendon Press, 1913), p. 243.

[3]Cited from his Contemplation of Mysteries (1571) in: S. K. Heninger, Jr., A Handbook of Renaissance Meteorology (Durham, N.C.: Duke University Press, 1960), p. 149.

[4]This comet is now designated as Comet Moestlin.

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Ptolemy and the like for his star positions and motions of the planets, but his observations had shown him that they were not correct. But now:

> A few years ago, I began to observe the places of the fixed stars and planets better with a great quadrant which was divided into single parts of a minute of arc and by a radius or astronomical rule whose length is 13 or 18 feet. However, I found, unfortunately, that there were discrepancies in the tables and in the heavens which, God willing, I will demonstrate by other works.[1]

He took observations with his radius of both the comet and the nearby stars. Then, employing spherical trigonometry, he derived the right ascensions and declinations.[2] He began with an observation of 2 October at Backnang and continued (although not daily) until 3 November, at which time his family was very ill and the negotiations for his position at Heidelberg took precedence. While at Heidelberg, he again observed it, but bad weather intervened at home. His last observation was made at Backnang on 12 December (he had to move his family to Heidelberg). His observations of this comet were not nearly so extensive as for the previous comet: he had had more distractions during this period, and the weather had not held up so well.

The next chapter (IV) gives the particulars on the comet's motion. He reviews its motion with respect to the ecliptic and says it moved slower at first but increased its speed as it neared the position of the sun, especially around 13 October when its longitude was about 1° of Pisces and the mean sun was in the first degree of Scorpius. He then gives the comet's angular relations to the planets and the sun.

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[1]Maestlin, Consideratio & Observatio, pp. 16-7.

[2]This was a refinement of his method of transversals. With an instrument instead of a thread, his accuracy would have improved somewhat.

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He was interested particularly in the fact that this comet had ignited in Aries, a fiery sign, and was consumed in Sagittarius, also a fiery sign. The comet of 1577 had ignited in Scorpius, a watery sign, and was consumed in Pisces, also a watery sign.

In the last chapter Maestlin tries to show that the comet was a supra-lunar object. With the comet of 1577, he had been able to conclude that the comet lay in the sphere of Venus. For the comet of 1580, he could not yet decide its true place in the heavens, although he thought it would be in the spheres of either Mars, Jupiter, or Saturn. The assumption of negligible parallax could show that the comet was in the aether. Any further conclusion must rely upon physical causes rather than observations and geometrical demonstrations. It was the nova of 1572, he says, that first led him to question the Peripatetic motions of the heavens and celestial bodies. He then became certain that the current interpretation (from the opinions of the ancients) on the places, motion, material, etc. of comets was incorrect. The astronomer, he says, cannot rely upon physical causes.

The last section is astrological: he again refrains from specific prediction. However, the comet's appearance, coupled with the chasms seen before and after its passage, led him to believe that terrible events would occur--even worse than an attack by the Turks. Yet he did not think that infected airs, colds, fevers, and the like would result from the comet's passage. He says that since he will turn to God, everyone should do so as well.

The Consideratio & Observatio was not as innovative as his earlier cometary work, and in it Maestlin did not mention Copernicus except in an aside. He did, nevertheless, reaffirm that comets are

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celestial objects which conform to astronomical laws. He also maintained his dissatisfaction with the Aristotelian views on comets.

He observed the nova of 1604 ("Kepler's Star") in Tübingen, and he wrote a short tract on his observations which Kepler saw; the manuscript[1] was never published. While he never published a proposed (and at least partially written) work on the great comet of 1618, his De Cometa Anni 1618[2]; it should be described briefly. The work is said to have been published in 1619, but the work seems to be a bibliographical ghost.[3] That it was intended for publication is clear both from the corrections in the manuscript and the comment of Christopher Besold who, writing to Kepler on 1/11 January 1619, stated that Maestlin was hard at work preparing a large and complete treatise on the comets.[4] The work in Stuttgart is not large and complete; he may have shelved the project, or the complete manuscript may have been lost.

Three comets appeared in the latter half of 1618, of which the third and brightest shone from November 1618 to January 1619. The comets were the subject of many tracts, including those of Horatio Grassi and Galileo in Italy, whose polemic raged for several years. The first two chapters of Maestlin's work are badly scored and practically illegible;

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[1]Part of the manuscript is in the WLB: Cod. Math. 4° 15[b] nr. 11. The MS is badly scored and illegible.

[2]WLB Cod. Math. 4° 15[b] nr. 8.

[3]Listed as No. 4750 in Ernst Zinner, Geschichte und Bibliographie der Astronomische Literatur in Deutschland zur Zeit der Renaissance (Stuttgart: Hiersemann, 1968) [hereinafter cited as Zinner, Bibliographie]; his information came from Steiff, who had not seen a copy. Zinner says that Grau claimed it was printed by Theodor Werlin in Tübingen in 1619. Martha List, in a private communication of 7.12.1970, says the work was in Stuttgart, but Dr. P. Amelung of the WLB (in a communication of 18.1.1971) states that the library never possessed a copy and that it was probably nonexistent.

[4]GW XVII, No. 822, p. 313.

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judging from readable lines and his previous cometary works, I would suppose that the chapters gave a general description of the comet. The third chapter describes the comet's path; Maestlin had observed it from 25 November to 13 January, but had made few observations. The fourth chapter gives the philosophical arguments in favour of the comet being either in the air or in the aetherial regions. The fifth chapter gives an explanation of parallax and its use in cometary theory. The following chapter asks whether the comet had a sensible parallax; answering in the negative, Maestlin concludes that this comet was in the aetherial regions. The seventh chapter reviews other comets that had been in the aether: the New Star of 1572, the comets of 1577, 1580, 1585, 1590, 1596, 1607, and the New Star of 1604.[1] He had observed both novae and the comets of 1577 and 1580; other observations, some by Tycho, led Maestlin to conclude that the other comets were also non-atmospheric. The last chapter of the manuscript contains arguments against Aristotelian cometary theory, a continuation of Maestlin's polemic against Peripatetic ideas. This chapter was probably not the final one; whether Maestlin completed the entire text, I do not know.

3.3 The Pedagogical Works

Besides his work on novae and comets, Maestlin also published two pedagogical works: his disputation on the principles of astronomy and his Epitome Astronomiae.

Maestlin's disputation on the fundamental principles of astronomy[2]

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[1]The comet of 1596 is now designated as Comet Brahe-Moestlin; I have found no mention of this comet in Maestlin's observations.

[2]Divino Rectoris Astrorum Favente Numine, De Astronomiae Principalibus et Primis Fundamentis Disputatio ad discutiendum proposita M. Michaele Maestlino . . . Respondente Hieremia Iacobo Ulmensi. (Heidelberg:J. Mylius, 1582). [Hereinafter cited as Maestlin, De Principalibus.]

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took place in Heidelberg on 20 January 1582 with Hieronymous Jacob as respondent. The work is short, and the theses are condensed and contain nothing new. After a discussion of astronomy as a mathematical rather than a physical science, Maestlin enumerates some of the features of the universe as he will expound upon it. He chooses the Alfonsine order and number of spheres (ten) and then gives what he considers are the eight fundamental principles of astronomy. In thesis XVIII he tells us that each sphere of the heavens is separate which is necessary for each planet's theory to be expounded. The second principle (thesis XXVIII) is that the motion of the heavens is always circular, while the third (thesis XXXVI) states that this motion is equal and regular. The fourth principle (thesis XXXIX) stands with the others and states that the world as a whole is spherical (or "rotund") as are all the spheres within it.

The other four principles deal with the earth: the fifth principle (thesis XLVII) is that the earth is a sphere; the sixth (thesis LIII) that the earth is in the centre of the world; the seventh (thesis LVII) comments on the insensibility of the size of the earth compared with the rest of the universe; and the eighth (thesis LXI) states that the earth is immobile.

These principles are, of course, entirely Ptolemaic, and Maestlin offers nothing new in their interpretation. The arguments for each principle are the standard ones to be found in Ptolemy, Sacrobosco, or any good textbook on astronomy (including Copernicus for some of the theses). In this work Maestlin does not depart from the rôle expected of him as a university professor. The disputation probably was a direct outcome of a project Maestlin had been working on for some time: a new textbook on fundamental astronomy, the Epitome Astronomiae, which, on 19 March 1582,

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was dedicated to Duke Ludwig of Württemberg.

During the sixteenth century, the Sphaera which was the thirteenth century text of John of Holywood (Sacrobosco), remained very popular as the elementary text for courses on astronomy in universities. Short and concise, Sacrobosco's work outlines the basics of the sphere. Late in the fifteenth century, two other textbooks joined it in the universities: Georg Peurbach's Theoricae Novae Planetarum[1] on planetary motions and Regiomontanus' Epitome in Ptolemaei Almagestum (first published in 1496) on Ptolemaic astronomy. Both works were easier to read than was Ptolemy's Almagest (first printed in Latin at Venice in 1515) and were widely employed in the universities along with books of a more popular nature, such as Peter Apian's Cosmographia. By the latter half of the century, three texts became favourites of teachers of astronomy: Christopher Clavius' In Sphaeram Ioannis de Sacrobosco Commentarius (1570 and many later editions); Francesco Giuntini's Commentaria in Sphaeram Ioannis de Sacro Bosco (1577 and later editions); and Maestlin's Epitome Astronomiae. The work of Clavius was immensely popular. Johnson claims[2] that only Maestlin's work seriously rivalled Clavius' commentary in the late sixteenth century.

Maestlin first published his work in 1582, but no copy of this edition seems to have survived. The second edition of 1588 has in the title "Now revised diligently by the same author." The work appeared at Heidelberg in 1582 but was successively reprinted at Tübingen in 1588, 1593, 1597, 1598, 1610, and 1624.

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[1] Editio Princeps: Nürnberg, 1472 (published by Regiomontanus), and many later editions.

[2] Francis R. Johnson, "Astronomical Text-books in the Sixteenth Century," in E.A. Underwood (ed.), Science, Medicine, and History (London: Oxford University Press, 1953), p. 301.

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Both the content and style of Maestlin's Epitome are different from that of most of his contemporaries' textbooks. The work employs a catechism structure (question and answer), later to be followed by Kepler for his own Epitome. The only sixteenth century example of this method in astronomical literature that I know of is that of Winshemius, whose book may have been used by Maestlin at school.[1] Recorde, in his Castle of Knowledge (1556), adopted a master-pupil dialogue form employed earlier in a variety of types of literature. Maestlin's method, however, did not employ dialogue. Besides the sphere, Maestlin discussed at length planetary theory. Peurbach had been his example although Peurbach had not discussed the sphere in his work. The works by Clavius and Giuntini chiefly discussed the sphere[2] so that, of the popular texts at the end of the sixteenth century, only Maestlin's was a comprehensive survey of astronomy.

Maestlin's dedication to his duke gives the reasons for his studying astronomy, and he supplies numerous references from the Bible. In his preface to the candid reader, he states that he will follow the method of Sacrobosco in expounding the fundamentals of astronomy; besides Sacrobosco, he will also draw upon diverse authors of astronomical works such as Peurbach, Regiomontanus, Theodosius, Reinhold, and Copernicus. Since Sacrobosco's Sphere is divided into four chapters, Maestlin also divides his work into four parts, the topics discussed by both following

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[1]Sebastian Theodoric Winshemius, Novae Quaestiones Sphaerae, hoc est, De Circulis Coelestibus, et Primo Mobili, in gratiam Studiosae iuventutis scriptae (Wittenberg: Iohannes Crates, 1564). Winshemius does not mention planetary theory in any detail.

[2]Giuntini does follow the catechism form like Maestlin but does not include planetary theory; the work adds little to Sacrobosco but has many diagrams which are seen in Winshemius, Maestlin, and others. Clavius' work does have commentaries on various technical aspects of planetary theory.

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roughly the same order. But where Sacrobosco is brief (or indeed totally uninformative), Maestlin is comprehensive and lengthy; the Epitome is over five hundred pages in length. Of course, Maestlin had not only Ptolemy's Almagest and his commentators but also Copernicus and Sacrobosco's commentators to draw upon.

Before the text proper, Maestlin included two poems dedicated to him by Johann Papius, a colleague at Heidelberg, and Thomas Fink of Flensburg. Like Sacrobosco, he felt that the student of astronomy should be aware of the elementary definitions of Euclid which were necessary for understanding astronomical terminology and to this end included a short "prolegomena" with concise discussions and explanations. Part one of the first book begins with a definition of astronomy and its goals, continues in part two to enumerate and explain the various parts of the world, and finishes in part three with the fundamentals of astronomy. He says he will include the artifices of both Ptolemy and Copernicus; his world-picture is the Alfonsine ten-sphere model, however. He discusses the material sphere and gives diagrams drawn from Peurbach and Peter Apian; the basic ideas of the motions of the spheres, the stars, constellations, risings and settings, and similar topics are recounted. In giving the periods of revolution of the spheres, he includes values of Copernicus along with those of Alfonso. For example, he describes the motion of the eighth and ninth spheres:

> [Question] What, therefore, are the specific periods of the spheres?
>
> [Answer] . . . the ninth sphere is restored, following the succession of the signs in one period of its own motion, according to Copernicus' demonstrations, in 25,816 Egyptian years. The sphere of the fixed stars completes its motion, according to Alfonso, in 7000 years, but according to Copernicus, in 1717 Egyptian years. This motion is called the motion of

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trepidation.[1]

Maestlin does not differentiate Alfonsine from Copernican trepidation at this point. He then turns to the earth: its place, sphericity, stability and other features, giving entirely orthodox descriptions and defense.

Throughout the first book are statements that Maestlin repeats in shorter form in his Heidelberg disputation of 1582, suggesting that the dissertation was drawn from the Epitome. Appended to the first book is a short discussion of the dimensions of the earth with sample calculations and methods.[2] In the 1610 edition, he enlarged the appendix to include the sizes of the spheres. The dimensions of the spheres are set out with both al-Fargani's and Copernicus' values. For the distance to the sun, he gives Ptolemy's maximum value of 1210 earth radii and compares it with Copernicus' range of 1094-1190 earth radii.

When comparing the values given for the distances with the stellar sphere, Maestlin comments on the physical difficulty inherent in such a view:

> This being noted, how immense and incomprehensible is the swiftness of the daily motion of the sphere of the fixed stars, or firmament. Therefore, if the altitude or radius of the firmament is 20110 [earth radii], that makes the whole of its diameter 40220 earth radii, which makes altogether (one radius being 860 German miles) 34,589,200 German miles. From that, according to the proportion of a diameter to the circle (as shown above) being 7 to 22, therefore the entire circumference of the firmament is 108,708,914 German miles. From this, through the 24 hourly divisions of the day, it follows that if you place a star on the celestial equator, in a single hour its movement would cover 4,529,538, i.e. more than four million, five hundred thousand German miles.[3]

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[1] Epitome (1588), p. 48.

[2] See above, section 2.4.

[3] Epitome (1610), p. 93.

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Copernicus, too, was struck by this incongruous speed:

> Among other reasons, this incomprehensible and incredible swiftness of speed was no doubt not the last, if not the first, that provided the occasion for Copernicus' thinking about other hypotheses and other dispositions of the spheres of the world so as to better correspond with reason, Nature, and the observations.[1]

Maestlin may have been led to this problem through his calculations for the appendix to Kepler's Mysterium Cosmographicum. There, in his preface to the Narratio Prima, he reviewed the values for the distances to the planetary spheres and touched on the immensity of the universe. While his arguments in the Epitome are not strictly pro-Copernican, neither are they neutral.

The second book deals in more detail with the material sphere and its motions. The first part discusses the circle and its measurement and the eccentricities of circles in the heavens. The second part then gives a summary of spherical astronomy, describing equinoxes, longitude and latitude, the zodiac, ecliptic, colures, the horizon, meridian, tropics, poles, etc. At that point, Maestlin appends a discussion of zones on the earth, an ancient and mediaeval topic. The third part takes up the necessary ideas for the theories of the planets: circles of spheres, eccentrics, epicycles, equants, eccentrics of eccentrics, and deferents. Although the definitions are given for Ptolemaic astronomy, Maestlin occasionally gives the usage of Copernicus when the latter has a different word or phrase for a construct.

The third book, like Sacrobosco, explains certain apparent motions and practical astronomy. The first part deals with right and oblique ascension with tables, the second part with risings and settings of the

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[1] Epitome (1610), pp. 94-5.

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stars and planets, and the third with time. The last part defines and explains both natural days and artificial days, both astronomical and civil years, and so forth. The fourth part deals with the prime mover. Appended to the third book are two geographical appendices, the first being a discussion on climates and the second on antipodes and the like, again mediaeval topics. In this book are several examples of observational methods. In one example, he gives the value of the obliquity of the earth's axis as $23^{\circ}28'$; this compares, he says, with Ptolemy's value of $23^{\circ}51'20''$ and with Copernicus' limits of $23^{\circ}52'$ and $23^{\circ}28'$. He chooses the latter, which Regiomontanus measured about 1460 from Vienna.[1] He adds that the celestial equator can be located by observing the altitude of the sun on the meridian at the solstices, the mean altitude being that of the equator. The north celestial pole can be located by choosing a circumpolar star and finding its altitude at upper and lower transits of the meridian -- the difference giving the altitude of the pole.

The first part of the fourth book takes up the separate theories of the planets, a topic ignored by Sacrobosco completely. Maestlin generally follows the treatment of Peurbach but includes the parameters of Alfonso and Copernicus; Copernicus' lunar theory is given some space but his planetary theories are ignored. To this part is appended a short discussion of the possible ways of interposing eccentrics and epicycles and eccentrics of eccentrics to account for the apparent motions of the sun, moon, and planets. The combinations employed by Copernicus are cited in this appendix as well. The second part of the book gives a detailed

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[1] Regiomontanus had found the altitude of the sun at summer solstice to be $65^{\circ}6'$, that of the winter solstice $18^{\circ}10'$. The mean was $41^{\circ}38'$ (the altitude of the celestial equator). Therefore, both solstitial altitudes are $23^{\circ}28'$ distant from the celestial equator.

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account of the "passions" of the planets, i.e. their stations, retrogradations, brightnesses, phases, velocities, and aspects. These passions are divided into four genera.

In the last section of part two, on eclipses, Maestlin not only gives a clear account of how eclipses take place but also introduces his own observations as examples. His observations of the lunar eclipses of 1572, 1577, and 1580 are mentioned with diagrams along with his observations of the partial solar eclipse of 1579. He also includes occultations in the category of eclipses, employing his own observations of the occultations of Cor Leonis by Venus in 1574, Mars by Venus in 1590, and Jupiter by Mars in 1591.[1]

Part three of book four has a discussion of the stellar sphere and its motion. Maestlin, although he had Copernicus' explanation at hand, chose to follow Alfonso's interpretation, including trepidation. Yet he suggests that there is an alternative, but "nevertheless, that would be more difficult and, besides, it would demand a lengthier explanation than we can give here at present, so we cannot treat of them here."[2] Here, Maestlin takes the stance of Robert Recorde[3] in the Castle of Knowledge: the pupil will hear of these ideas after he has mastered the fundamentals of the science. The Epitome closes with an appendix on measuring terrestrial distances.[4]

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[1] Several of these observations are included in MS cod. Vindob. 10 887. Maestlin added these observations in the revisions of the Epitome. Those observations mentioned above are in the 1597 and 1610 editions which I have seen. Fewer are mentioned in the 1588 edition.

[2] Maestlin, Epitome (1597), pp. 499-500.

[3] There is no mention in any of Maestlin's works or letters of Recorde.

[4] See above, section 2.4.

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Revisions in the various editions were minor, including new observations and slight changes in wording but no major additions or corrections. It is obvious that Maestlin had in mind a sound textbook on astronomy that could be used in the universities. That he chose not to make his epitome a Copernican work should come as no surprise, although by that time he was a Copernican -- for this work was intended as a text and was very popular. Kepler's Epitome went through only two editions and would not have found a place among general university texts. Maestlin must have been unhappy with the texts he had at his disposal and decided to write one for his own classes (he seems to have required it both at Heidelberg and Tübingen). As I shall show below, Kepler not only used Maestlin's work as his basic text but borrowed his method as well. Caspar's contention that:

> To be sure, in his public lectures, as well as in all editions of the Epitome, the astronomy professor sides completely with the system described in Ptolemy's Almagest, because the Copernican theory was strictly prohibited among his theological colleagues, due to its supposed contrariness to Holy Writ.[1]

is gratuitous, for Maestlin had come out publicly for Copernicus in 1578 and gave many references to Copernicus in the Epitome; besides, evidence of theological opposition is scant before 1596. Maestlin's work was not a great scientific book but was sound pedagogy. Perhaps Delambre's comment is the best:

> His Epitome is, in effect, no more than what he promises, that is to say a compilation of that which is found in the authors that preceded him, those of Peurbach, Regiomontanus, Copernicus and others.[2]

3.4 Maestlin's Astronomical Weltansicht.

Drawing from Maestlin's major works and correspondence, I would

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[1] Caspar, Kepler, p. 49.

[2] Delambre, Histoire, I, p. 312.

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like to give an idea of where he stood on some of the more important issues in astronomy in his day, especially with regard to Copernicanism.

It is difficult to think of astronomy today in any light other than a strict scientific discipline, closely allied with physics and relying heavily on mathematics. The astronomer of the sixteenth century rarely thought of himself in this light. The average astronomer was also an astrologer -- the end product of his observations and calculations was the means by which he peered into the future. Few questioned that the planets and stars affected man in some way; most astrologers, however, sought to find a causal link between specific planetary alignments and specific terrestrial or human events. Comets offered the astrologer of this type an excellent portent of events. The vast astrological literature resulting from the new stars of 1572 and 1604, and especially the comet of 1577, underscores the interest in prognostication. Judicial astrology, the casting of personal horoscopes, was even more addictive than general prognostication. Although it was illegal throughout most of Europe, it was practised assiduously. In the sixteenth century, astrology was still acceptable to nearly everyone in society: by the physicians for their diagnoses, by rulers and generals for political prescience, and by preachers for practical religion. Indeed, the Church, whether in its Catholic or Protestant form, sanctioned and constantly employed prognostication. Judicial astrology, the common horoscope, was frowned upon; it was, nevertheless, tolerated by many churchmen. Pico della Mirandola, the harsh Renaissance critic of astrology, was the exception rather than the rule.

Michael Maestlin had little interest in this pseudo-science. There are no horoscopes by his hand in his collected manuscripts. Indeed,

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in a Stuttgart manuscript there is a request for a horoscope to be cast for a child, and Maestlin wrote, upon the request:

> The astrological opinion that is asked of me I am unable to write, nor do I have the skill, because both publicly and privately I have often protested [against it]. . . I have never undertaken astrology.[1]

There are a number of horoscope diagrams in the Stuttgart manuscripts, but none seem to be in Maestlin's hand, although there are annotations in his handwriting which usually give astronomical details. In his work on the new star of 1572, Maestlin refrained from making any predictions, and in his work on the comet of 1577, he made it clear in the preface that others could make predictions; however, the last chapter of that work includes some general significations of the comet, an almost necessary addition to any work on such a phenomenon. His work on the comet of 1580 also has some general astrological remarks. The Epitome refers to astrology only in passing,[2] and his disputation on the principles of astronomy makes no particular mention of astrological predictions.

In a letter to Kepler of 2 May 1598 (O.S.), Maestlin comments on his pupil's predictions for 1598, saying:

> I see you haven't given up astrology . . . But I, and certainly others with me were greatly astonished how you, in your prognostication for 1598, criticized it so much. You answer in that letter that you confute not astrology, but the useless instrument of the numbers of houses and special predictions, arrogant presumption, etc.[3]

Maestlin's position on astrology was much different from that of his contemporaries, Tycho and Kepler. While both of them occasionally directed a jaundiced eye toward judicial astrology, both produced horoscopes.

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[1] WLB. MS Cod. Math. $4^{o}15^{b}$ Nr. 55.

[2] He gives the zodiacal houses and defines the astrological trigons, etc.

[3] GW XIII, No. 97, 210.

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Tycho felt that astrology was a true branch of astronomy and never gave up either prognostication or the casting of horoscopes. He was aware that much of the astrology then practiced was nonsense, but he never gave up trying to find a true method of prediction. Kepler, who was obliged to cast horoscopes and make predictions out of poverty and position, likewise thought that a true, deductive science of astrology could be created; he grappled with that problem in a number of works.

Whether Maestlin felt there was a scientific basis to astrology is unclear; he was certainly opposed to casting horoscopes and made as few predictions as possible, and those with obvious distaste. He felt that his time should be spent trying to improve astronomy.

In his attitudes toward the proper method in astronomy, however, Maestlin was a traditionalist. In his disputation on the fundamental ideas of astronomy,[1] he asks whether astronomy ought to be referred to physics or to mathematics. By physics, he would refer to the Aristotelian idea of that science which was definitely non-mathematical; questions on the matter of the universe and its motion were irrelevant to astronomy. He argues that mathematics (i.e. geometry and trigonometry), not physics, must be used to demonstrate celestial motions. Of mathematics, Maestlin accepts two species: the discrete and the continuous. The discrete is employed in arithmetic and in music, whereas the continuous is employed in geometry and astronomy: geometry being immobile continuity and astronomy mobile[2] -- a traditional classification. It is clear that Maestlin, like all his predecessors, accepted an entirely kinematical astronomy, and any attempt at a dynamical astronomy would fall into the category of

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[1] Maestlin, De Principalibus, p. 1.

[2] Ibid., pp. 1-2.

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physics, which he rejected.

In the Epitome, Maestlin affirms this position and with the appearance of Kepler's work, the Mysterium Cosmographicum, he was induced to press the point. Kepler's idea of the harmony of the spheres by using the five regular solids was acceptable to Maestlin, who defended the idea to the Tübingen authorities and praised Kepler's conclusions in his own appendix to the work. Kepler, however, was fond of seeking physical causes, which Maestlin could not readily accept. Writing to Kepler soon after the publication of the work (9/19 March 1597), Maestlin says:

> I do not reject that speculation [of yours] on souls and moving virtues. Yet, I fear it would not be very subtle if carried far. That is how it is as you move the moon. I am really afraid if carried to its extreme conclusion, it will draw after it the loss and certainly the ruin of the whole of astronomy. I generally think of using this speculation very moderately and with restraint. And that I may really say that I believe: I do not reject it, but really, my approval of it is weak, for the contraries very much raise opposition in me.[1]

Several times in his correspondence with Kepler Maestlin chided him for placing too much emphasis on forces or intelligences as physical agents. He was not absolutely opposed to their use, but his reservations, conditioned by his education and his intellectual predilections, kept him from being too full of praise for their use and from employing them himself.

On the method of discovery in astronomy Maestlin drew closer to the view of Kepler than to that of Tycho Brahe, who criticized them both for their version of it. Until the time of Kepler's Mysterium Cosmographicum, Maestlin could be placed with most astronomers in believing that the arrangement and distances of the spheres would be found only a posteriori, that is, by the careful compilation of observations. Copernicus had stressed the collection of careful observations if accurate tables were to

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[1] GW XIII, No. 63, 111:127-38.

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be made; the true astronomer must rely upon observational evidence and careful calculation. This Tycho Brahe believed firmly, and Maestlin, with his own programme of careful observation, would agree with him. With Kepler's so-called discovery that the planetary spheres are predetermined by intervals created by God with the five regular solids, Maestlin, however, who saw this discovery as God given, had to admit the a priori approach to astronomy. He praised Kepler's method in the preface to Rheticus' Narratio Prima, appended to the Mysterium Cosmographicum, and claims:

> Thus, from this time forth, he who inquires fully into the motions of the heavens, which in astronomy have hitherto been imperfect, and wishes to revive and restore [astronomy] now has, a priori, an open door which he can enter, and he has a most correct rule to which . . . he can compare all his observations and all of his calculations.[1]

Maestlin wrote to Hafenreffer at Tübingen on behalf of Kepler in the same vein.[2]

Tycho, when he saw both Kepler and Maestlin adopting such an attitude, was critical. In 1598, writing to Maestlin (whom he knew was in favour of better observations), Tycho attacked Kepler's and Maestlin's use of the a priori:

> If the improvement of astronomy ought to be made rather a priori, by means of the regular solids, than a posteriori, on the grounds of the knowledge of observational facts, as you have thus suggested, we will certainly have to wait a long time, if not forever and in vain . . .[3]

Tycho had, of course, a stake in an a posteriori astronomy: he hoped to use his observational data to insure the success of his own system of the

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[1] GW I, 82:39-43.

[2] Letter of 31 May 1596 (O.S.). GW XIII, No. 43, pp. 84-5.

[3] Letter of 21 April 1598 (O.S.). GW XIII, No. 94, p. 204.

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world. His system was a distinct possibility as long as there was no underlying a priori arrangement (and a Copernican one at that) for the universe.

One of the most interesting facets of Maestlin's ideas on astronomy is the rôle he thought himself to play in the science. He had written to Rudolf II in 1579 for an Imperial licence to publish his Ephemerides Novae and a number of subsequent works. The Diploma of Privilege was duly received in 1580.[1] Maestlin listed the works he would publish beginning, after the Ephemerides, with a compendium of astronomy which would include an explanation and commentary on the sphere and would describe the theories of the planets and the motion of the fixed stars. This Maestlin produced in 1582, his Epitome Astronomiae.[2] Then, he planned to write a "vulgar arithmetic" and produce a work on the doctrine of plane and spherical triangles. Neither of these works appeared, although there are fragments of drafts in Stuttgart.[3] A commentary on the Sphere of Theodosius[4] would follow (which never appeared), and a complete treatise on the uses of the shadow of the gnomon and the elevations of the stars to tell time during both day and night would be printed. Fragments of what may be this work are in manuscript, but no printed work was forthcoming. As an addition to this work, Maestlin would write a treatise on the instruments necessary along with planometrics and stereometrics. No sign of this work seems to exist. All these works could have been written,

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[1] HAB MS Cod. Guelf. 10.5 Aug. 2°. Dated Prague, 5 April 1580.

[2] The Epitome and the Ephemerides Novae are the only works bearing "with Imperial Privilege."

[3] See above, section 2.4.

[4] Theodosius' Spherica, dating from c. 100 B.C., was first printed in Paris in 1529.

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but Maestlin's next projected works were of a much more ambitious nature. He promised to write a Revolutions of the Heavenly Spheres in imitation of Ptolemy and Copernicus. Being a Copernican, he doubtless planned a revised version of Copernicus' work based on his own observations and those of his contemporaries to produce a much more accurate work. Drawing from this De Revolutionibus, he would produce a new set of tables like those of Alfonso and Reinhold.[1] Once these new tables were produced, he could then publish a set of resolved tables "like those of Bianchini"[2] and an improved ephemeris for the public.

Needless to say, this ambitious programme never materialized. It was to be his student Kepler who, in large part, completed this programme. Although the Tübingen astronomer had to drop his great scheme early (partially on account of the controversy surrounding the Gregorian calendar reform), his influence was to some extent responsible for its later completion.

The primary importance of Maestlin in the history of astronomy was his early and unusual adherence to the Copernican system of the world. Until very recently, practically every historical work dealing with Kepler and Maestlin states that the latter taught only Ptolemy publicly, from fear either of scorn or of condemnation by orthodox religious leaders, or because of the wish to retain his coveted academic position. Indeed, some authors have Maestlin teaching Copernicanism secretly to small groups in which Kepler found himself. I will endeavour to show in

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[1]The Alfonsine Tables and Prutenic Tables were computed from planetary theory (Ptolemy and Copernicus respectively) and, reckoning from an epoch, gave the motions of the sun, moon, and planets. Detailed ephemerides, calculated for a specific geographical location, were drawn from the general tables.

[2]Maestlin here refers to the popular Coelestium motuum Canones

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this section that the accepted historical view of Maestlin's position on Copernicanism is false, if not absurd; indeed, it can be shown that he did much to publicize and improve the heliocentric hypothesis.

There is no evidence that Maestlin was drawn to Copernicus by his teacher Philipp Apian. The latter seems to have been entirely orthodox in his astronomical views, and his choice of textbooks underscored his acceptance of the Ptolemaic scheme. Indeed, when Maestlin arrived in Tübingen, few astronomers upheld the Copernican doctrine in Europe. In Germany, prior to 1570, only Rheticus and perhaps Reinhold can be considered to have been Copernicans. Rheticus did more, perhaps, than anyone to publicize the ideas of the Canon of Frauenberg, both through his Narratio Prima and his inauguration of the printing of De Revolutionibus. If in his later years Rheticus seems to have had second thoughts, his work for the hypothesis' propagation was nevertheless complete. His earlier associate at Wittenberg, Reinhold, almost certainly not a confirmed Copernican, did the hypothesis a signal favour by the publication of his Tabulae Prutenicae in 1551. The tables of Stadius, Leowitz, Magini, Origanus, and, of course, Maestlin leaned heavily on Reinhold's work. Yet employing the Prutenic Tables was not synonymous with avid Copernicanism: of these five authors, only Maestlin was an avowed Copernican. Indeed, Magini and Origanus specifically repudiated all but the observational part of De Revolutionibus.

Of Maestlin's contemporary astronomers in Germany, only the Landgrave Wilhelm IV of Hesse-Kassel and Christopher Rothmann (fl.1580-90)

(1495) of Giovanni Bianchini (fl. ca. 1450); the tables were based upon Alfonso and reduced for the meridian of Ferrara.

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were Copernicans of note. In England, both Robert Recorde (1510-58) and Thomas Digges (? -1595) had mentioned Copernicus early, the latter possibly being a Copernican. In Italy, so little was written about Copernicus that in the Catholic condemnation of the hypothesis in 1616, only a Carmelite Father, Paolo Foscarini and a Spaniard, Didacus à Stuñica were mentioned as upholding the doctrine that the earth could move.[1] The works of Bruno were condemned earlier on other grounds. From this it should be evident that Maestlin was a member of a tiny band of Copernicans in the sixteenth century. Far more typical was the anti-Copernican literature of the period written by adversaries such as Tycho Brahe, Raimers Bär, and many other astronomers, as well as the Lutheran churchmen from Luther and Melancthon down.

Exactly when and how did Maestlin become convinced of Copernicanism? Although there is no certainty as to whether Apian taught any of Copernicus or not, I think it is reasonable to assume that the heliocentric theory would have been mentioned in passing. Both Copernicus' De Revolutionibus and Rheticus' Narratio Prima were available[2] for an astronomy student to read. Maestlin was certainly familiar with Reinhold's Prutenic Tables from an early date: he seems to have added an afterword to the 1571 Tübingen edition of that work,[3] and his observations employed that work

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[1]See Ludovico Geymonat, Galileo Galilei (New York: McGraw-Hill, 1965), pp. 86ff., and Giorgio de Santillana, The Crime of Galileo (Chicago: University of Chicago Press, 1955), pp. 110ff. Foscarini published a pro-Copernican work, his Letter . . . on the opinion of the Pythagoreans and of Copernicus . . . (Naples, 1615); Zuñiga was probably not a Copernican, although he had shown in his Commentary on the Book of Job (Toledo, 1585; Rome, 1591), that the motion of the earth was not contrary to scripture.

[2]Copernicus' work was published in Nürnberg in 1543, Rheticus' at Basel in 1541; both were published together in Basel in 1566 by Henricpetri.

[3]See Appendix B, Item 1.

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from 1572 for certain. But this would not have acquainted him with the Copernican theory as such.

Maestlin's own copy of the De Revolutionibus was the edition of 1543. According to Zinner,[1] this copy is now in the library at Schaffhausen and has on the title page: "Ex libris M. Michaelis Maestlini Goeppingensis, Anno Domini 1570." The date may refer to the time of acquisition, though Maestlin did not technically become a Master until the following year. For him to purchase this work in 1570 seems to point to at least some interest being aroused by Apian, although not necessarily positive. Alongside Osiander's preface, Maestlin had written: "And since I cannot approve of all this vague and simple-minded letter, therefore, much less can I defend it."[2] There is no indication when this comment was written, however, or the reasons for Maestlin's saying "therefore". Were this sentence to date from 1570, it would indicate that even then he could not accept Osiander's view that Copernicus' work was only hypothetical. Later evidence seems to militate against such an early date.

Beneath this statement is another of interest: "N.B. I found out for certain that the author of this letter was Andreas Osiander."[3] Maestlin notes that he found this information "among the books" of Philipp Apian (which he had purchased from Apian's widow) and describes

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[1] Ernst Zinner, Enstehung und Ausbreitung der Coppernicanischen Lehre [Sitzungsberichte der Physikalisch-Medizinischen Sozietät zu Erlangen], Bd. 74, 1943 (Erlangen: Max Mencke, 1943), p. 453. [Hereinafter cited as Zinner, Enstehung und Ausbreitung.]

[2] Ibid., p. 453. "Ideoque ego indistincte et simpliciter omnia huius epistolae capita non approbare, multo minus defendere possum."

[3] Ibid.

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in the ensuing paragraph the story of how Rheticus handed over to Osiander the task of seeing the book of Copernicus through the press. An identical paragraph is written into another copy of De Revolutionibus in Munich[1] (possibly Apian's). As Apian died in 1589, Maestlin would have gained that knowledge looking through the works he had purchased; the above-mentioned note alongside Osiander's preface could have been written at that time, when Maestlin was certainly a Copernican. Of course, he may have had access to the books of his teacher at an earlier date. Where Apian might have learned of Osiander's authorship I cannot tell, although the Osiander family lived in the Tübingen neighbourhood at the time, and Apian might have heard the story directly from one of the family. It was Kepler who finally publicized the true authorship of the letter in 1609, having heard the story from another source.[2]

From his student days, then, Maestlin had the De Revolutionibus and the Tabulae Prutenicae and, quite probably, the Narratio Prima at his fingertips. But then, so did many astronomers at the time. Just what convinced Maestlin that Copernicus' ideas were more than a hypothesis constructed to "save the appearances"? It was the two celestial events of great proportion -- the new star of 1572 and the comet of 1577. As was shown above, the nova of 1572 convinced Maestlin (as it had Tycho) that Aristotle's opinions on the immutability of the heavens simply were false. This idea does not necessarily lead to the adoption of Copernicanism, as shown by the case of Tycho. Yet sufficient doubt may have been sown in Maestlin's mind which would later bear fruit. Since Aristotelian physics and Ptolemaic astronomy were wedded in the Renaissance

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[1] Zinner, Enstehung und Ausbreitung, p. 453.

[2] Dreyer, History of Astronomy, p. 321.

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world-view, suspicion of either one could lead to questioning of the other. Maestlin makes no pro-Copernican statement in his little treatise on the new star, but his doubts of Aristotle began with that.

The comet of 1577 produced a different reaction. In his work on the comet, Maestlin took the Copernican theory of Venus to be the only one adequate to explain the comet's motion. As he said, he was reluctant to give up the accepted notions, but he was a friend of truth above all.

It would be to 1577 or 1578, then, that we could date the acceptance by the Tübingen astronomer of the heliocentric astronomy. But nearly a decade of study and observation preceded his acceptance; Maestlin's newly-proclaimed adherence was not blind. It was not simply that the comet was in an orbit best described by a Copernican model that would lead Maestlin to this view, but also the fact that the comet lay in the aetherial regions, which directly contradicted Peripatetic cometary theory. The new star and the comet, both in the aetherial regions, appeared as cracks in the otherwise monolithic structure of Ptolemaic-Aristotelian natural philosophy. Had he felt any regret or doubt before, the appearance of the comet of 1580, also in the aetherial regions, must have left him with no question.

The two works on astronomy written in Heidelberg in the eighties, the disputation on the principles of astronomy, and the first edition of the Epitome Astronomiae were orthodox in character. Once, in that disputation, Maestlin mentions the Copernican doctrine but says that he will follow the order of spheres "according to Alfonso the Wise", for the opinion of Copernicus would not be appropriate for such a discussion.[1]

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[1]Maestlin, De Principalibus, thesis XXV. This was precisely the tactic followed by Galileo at Padua up to 1606 at least.

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The Epitome, as I argued above, was simply a textbook written in the traditional style. That Maestlin did not write strongly pro-Copernican texts in Heidelberg would result from the simple fact that he was paid to teach orthodox astronomy. If he also had a distaste for "rocking the boat", he was not unlike a good many academics of today in their first positions. Even in the Epitome, he subtly shows he is not strongly Ptolemaic with such statements as "Secundum usu receptam sententiam statuimus, terram in medio mundi sitam esse."[1] A similar statement is made in the 1582 disputation.

Although Maestlin's first public confession of Copernicanism was in his work on the comet of 1577, his major contribution to the spread of Copernicus' doctrine lay in his additions to Kepler's Mysterium Cosmographicum of 1596. Kepler asked him to include an appendix showing the distances of the spheres of the planets according to Copernicus. This appendix, De Dimensionibus Orbium et Sphaerarum Coelestium Iuxta Tabulas Prutenicas, ex sententia Nicolai Copernici[2] described the theories of all the planetary orbs according to Copernicus and calculated their distances from the sun rather than from the centre of the earth's orbit. Even this appendix might be construed to have been only hypothetical, but Maestlin had shown his true colours by appending (without Kepler's foreknowledge) a new edition of Rheticus' Narratio Prima. He felt the work would help the readers of Kepler's book by clarifying the discussion of Copernican theory. He revised the work[3] and supplied figures to the text by taking

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[1]Maestlin, Epitome (1597), p. 73. Italics mine.

[2]The original ran from page 161 to 181 in the 1596 edition. Also, GW I, 132-145. The appendix was not printed by Frisch.

[3]These revisions are duly noted by Rosen, Three Copernican Treatises, (New York: Dover, 1959), pp. 114ff.

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diagrams from the De Revolutionibus and transposing the figures to agree with Rheticus' text.[1]

To this edition of the Narratio Prima, Maestlin wrote a new preface which makes clear his position in the debate. He acknowledges the great discovery by Kepler of his a priori arrangement of the heavens in the Copernican order. Maestlin is unhappy that many have "illegitimately condemned" the Copernican hypothesis as "absurd". In his thinking, those who doubt should turn to Copernicus himself in the first chapter of Book I where the reasons for adopting the heliocentric view are given; Rheticus and Kepler have given reasons as well. To overcome the physical difficulties raised by the Copernican hypothesis, Maestlin thought that men should look for an alternative view to Aristotelian physics. He says:

> . . . of the reasons by which they fix the earth motionless in the centre, the greatest argument, I have assumed, is from the motion by heavy and light things, because heavy objects are said to tend toward the centre of the world, and light ones away from it. But I ask how we gain this experience of light and heavy? And how far by us these notions are extended, so that we can with certainty argue about the centre of the whole universe? Are not the seats and residences of all the air around the earth? But what is the earth and its moving air with respect to the vast immensity of the whole universe? They are a point, or punctule, and if anything, they have reason to be called less.[2]

This was a new note in Maestlin's polemic against Aristotelian natural philosophy. Here was a crucial point that had to be resolved. Unfortunately, without the concept of universal gravitation, Maestlin could only argue philosophically about heaviness and lightness elsewhere in the universe:

> . . . as Copernicus so eruditely discusses in Book I, chapter

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[1] GW I, p. 85.

[2] Ibid., p. 83:17-25.

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> 9, it is credible that an affection may even be in the sun, moon, and other bright planets, such that by the efficacy [of this affection] they maintain their spherical shape, as we perceive them. But should this place [where the affections are centred] somehow be the centre of the world, it could only happen to be so by accident. Truly, Copernicus' astronomical doctrine does not proceed from the particular, or smallest parts to the whole; they proceed from the whole to the parts.1

Since Maestlin had never been interested in physical reasoning in astronomy, he relied upon the philosophical arguments given before him by Copernicus.

A better reason is advanced. If any of the spheres in Copernicus' system are moved, the entire structure is destroyed. Since the heliocentric hypothesis is a system, the astronomer can ascertain the true order and dimensions of the universe. This cannot be done in orthodox astronomy, for the ancients did not even know the true order of the planets. Some have said there are ten spheres, others eleven. How the sun, Mercury, and Venus are ordered no one knew. Excepting the distances to the sun and moon, which could be determined by trigonometry, the distances to the spheres could not be found.[2] Maestlin went on to discuss the immensity of the world, giving some figures from al-Fargani, al-Battani, and others. Armed with such data, he could bring forth Copernicus' argument against the implied (and absurd) great velocity of the stellar sphere.

Maestlin's interest in the propagation of the Copernican

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[1] GW I, p. 83:30-35.

[2] This was not entirely true. Mediaeval astronomers, following the method first outlined in Ptolemy's Hypotheses of the Planets, could get an estimate of the distances to the spheres beginning with the distances to the moon and the sun. This did not, of course, solve the problem of the order of the spheres. See Bernard R. Goldstein, "The Arabic Version of Ptolemy's Planetary Hypotheses," Transactions of the American Philosophical Society, N.S. Vol. 57, Part 4 (1967).

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doctrine continued long after 1596. Maestlin planned to edit a new edition of Copernicus' De Revolutionibus. In his own copy, he had made a number of corrections which he wished to incorporate in the new edition. Negotiations were attempted with Henricpetri of Basel, publisher of the 1566 edition, but the negotiations came to naught.[1] The project was shelved, and a new edition did not appear until that of Amsterdam of 1617, edited by Nicolas Müller.[2] He also expressed an interest to Kepler that the Narratio Prima be retained for the second (1621) edition of the Mysterium Cosmographicum, which was duly printed with a few additions to both preface and text by Maestlin.

Shortly after the publication of Kepler's first major work, Maestlin disputed Copernicanism with the Tübingen theologian Matthias Hafenreffer:

> Dr. Hafenreffer has attacked me more than once (jokingly indeed, still, the joking was seen to be mixed with seriousness). He disputes with me, all the time defending his Bible, etc. The same one, not so long ago in the evening assembly publicly preached in explication of the first chapter of Genesis that God did not hang the sun in the midst of the world like a lantern in a hall, etc. Truly, I am accustomed to oppose those jokes jokingly, so long as they are jokes; if the thing might be taken seriously, I might be answering him in another way. For the same Dr. Hafenreffer expresses extraordinary fantasies and erudite inventions but thinks the Holy Scriptures are entirely sufficient to combat the truth. In truth, with those who hold the principles of these things insufficiently (although they might be great and most erudite men otherwise) it is simpler and more sufficient to do it jokingly, so long as they take it as a joke.[3]

Although Hafenreffer was a good, longstanding friend of Maestlin's, he obviously was unwilling to depart from his literal interpretation of

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[1] GW XVII, No. 651, No. 660, and No. 686.

[2] This edition did not include the "corrections" ordered by the Roman church in 1616.

[3] Letter to Kepler of 30 October 1597 (O.S.). GW XIII, No. 80,

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the Bible. If the theologians at Tübingen were unhappy about Maestlin's adherence to Copernicus, they might have censured him for writing an appendix to Kepler's Mysterium or, indeed, withdrawn permission for the work even to be printed. Maestlin did, it is true, advise Kepler to refrain from pressing the theological arguments surrounding Copernicanism; he was not afraid, but he was not foolhardy, either. Certainly he did not lose his teaching post for holding unorthodox views. He was highly enough regarded to be re-elected to the post of Dean of the Arts Faculty a number of times after the incident.

In the period of the first telescopic discoveries, Maestlin corresponded with Simon Mayr, who, in a letter to Kepler of 16/26 August 1613, said that Maestlin had written to him arguing that the sun was in the centre of the world and was not simply a planet like the others.[1] During this time, Maestlin's correspondence with Henricpetri was taking place; in 1616 or later, he had completed a new preface for the projected Copernicus edition.[2] Rejecting Galileo's attempts to free discussion on Copernicanism, the Congregation of the Index in Rome had promulgated a decree (1616) stating that Copernicus' work would be proscribed until such time as it was "corrected", to remove the pernicious doctrine of a moveable earth. The decree also prohibited the works of Foscarini and Didacus à Stuñica from being sold. A handwritten copy of the decree exists in the Maestlin manuscripts in Stuttgart. In the preface to his

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p. 151:21-32. This was one of the earliest theological attacks on Copernicus after Luther's "Tischrede" comments.

[1] GW XVII, No. 662, p. 73.

[2] The preface, printed in Frisch, is clearly to be placed before Rheticus' Narratio Prima, for he says it goes before the letter of Achilles Gasser. Maestlin may have, then, planned to publish both Copernicus and Rheticus together as in the 1566 Basel edition.

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intended edition,[1] Maestlin repeats the salient points of the decree, suggesting that the good Cardinals of the Congregation had not even looked at Copernicus' work and that, although they were undoubtedly learned in theology, jurisprudence, and other church matters, they were neither mathematicians nor astronomers. That non-experts should say whether a book could be published or not seemed wrong. He rightly points out that the Church had not bothered condemning Copernicus for more than three-quarters of a century, so why should it do so now? He could not give an opinion on the works of Foscarini and Didacus, as he had not seen them. The case of Copernicus has a parallel in church history: Vergil of Salzburg had been censured for a long time by the Church for teaching that the earth was spherical, when good Church Fathers like Lactantius had taught that the earth could not be round for the Bible said otherwise. Maestlin does not say whether or not he was aware of Galileo's struggle in Italy; he did not live long enough to witness the final showdown in 1633.

After 1596, Maestlin produced no further substantial astronomical works related to Copernican astronomy, but there is no reason to believe that he wavered in his adherence to heliocentric astronomy. From his efforts for the theory, his teaching (exemplified in Kepler), his publications, letters, and his quarrels with friends, I find it ridiculous to conclude with Koestler that " . . . astronomers like Maestlin were still either silent on Copernicus, or agreed with him only in cautious privacy."[2]

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[1] F I, pp. 56-8. See also, Wohlwill, Galilei und sein Kampf, II, pp. 2-3.

[2] Koestler, Sleepwalkers, p. 255, speaking of the period after the publication of the Mysterium, which makes the statement all the more curious. Koestler is by no means the only writer to make a statement of this kind.

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CHAPTER IV

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CHAPTER IV

MAESTLIN'S STUDENTS, FRIENDS, AND CONTEMPORARIES

4.0 Introduction

In this chapter I shall give a more detailed discussion of Maestlin's circle of friends, most important students, and correspondents. This discussion will indicate the social and intellectual milieu in which he lived, and may suggest a norm for the circles of friendship and communication maintained by contemporaries of similar stature. A number of contemporary or near-contemporary opinions of his work will be cited, along with indications of their sources of knowledge of his opinions. The initial and principal section of the chapter will be devoted to his most famous pupil Kepler who, more than any of Maestlin's other contemporaries, preserved his name and reputation for history.

4.1 Johannes Kepler

> There [at Tübingen] he came under the influence of Maestlin, the professor of mathematics, by whom he was in private taught the principles of the Coppernican System, though the professional lectures were still on the traditional lines.[1]

With these words, Arthur Berry epitomized the view that the majority of historians of science have, until recently, adopted with regard to Maestlin and Kepler's relationship. Kepler, the architect of modern astronomy, was unquestionably the most important student produced by the Tübingen astronomer in his long teaching career. It is primarily

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[1]Arthur Berry, A Short History of Astronomy (New York: Dover, 1961), p. 180.

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through Kepler's works that historians have learned of any detail of Maestlin's life and work. Although Maestlin has been mentioned in practically every biographical account of Kepler, he has always been seen from the viewpoint of his student; here I would like,in some aspects, to view Kepler from the point of view of his teacher.

Kepler came to the University of Tübingen in 1589 and enrolled in the Stift. His previous education paralleled that of his teacher: he had attended the klosterschulen and obtained his B.A. by examination at Tübingen prior to entry into the theological school. Like Maestlin, he was a scholarship student. Since he was obliged to enrol in the courses given to theology students by the arts faculty, he soon came into contact with Maestlin in the latter's mathematical and astronomical lectures. As noted above, no records remain describing Maestlin's lecture content at the time of Kepler's attendance; thus, we are left to guess the probable subject matter at the time. That Maestlin's own Epitome Astronomiae was employed as the textbook for astronomy seems to be a safe assumption (at the time the work had just been re-printed). The mathematical lectures would have included parts of Euclid's Elements; some geometrical problems of Apollonius and Archimedes may have been discussed. Whether Maestlin offered instruction in the use of instruments and observational techniques is unclear. Some instruction of an informal nature, such as student accompaniment on his observational sessions, may have taken place. There is some evidence later that this did occur. Of course, Kepler may simply have picked up a working knowledge of instruments and their uses. Certainly, the mathematics necessary for the reduction of observations was taught by Maestlin in the astronomical lectures (plane and spherical trigonometry being his mathematical specialties). Maestlin was also interested in algebra, but the likelihood

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of Kepler's knowledge of that subject being due to his teacher is slight.[1] We know that much of Kepler's mathematical knowledge was obtained after leaving Tübingen, and the sparsity of citations or references to Maestlin in Kepler's mathematical works supports the view that Kepler's later mathematics owes little to his teacher.

There is no doubt that Maestlin held a high opinion of Kepler from the latter's student days, for he maintained an active correspondence with the younger man for several years after Kepler's departure from the university. Kepler's first post, in Graz, was due in part to the advice of Maestlin to the Tübingen authorities. Maestlin's services to Kepler were indispensable at the writing of his first book on Copernican astronomy, his Mysterium Cosmographicum of 1596. Maestlin not only procured a publisher for the work, his own long-time publisher Gruppenbach in Tübingen, but also saw the work through the press--indeed a laborious task.[2] More important, Maestlin undertook the task of convincing the Tübingen authorities to allow the book's publication. The Lutheran officials were not particularly warm to a treatise on Copernicanism, and Kepler had exacerbated them by insisting on the inclusion of a chapter proving that Copernican astronomy was consistent with the Bible. With sufficient coaxing, however, Kepler was persuaded to suppress it. The publishing completed, Maestlin grumbled that he had earned a reprimand from the Senate for not submitting a promised treatise on the calendar reform; Kepler replied rightly (but for the wrong reasons) that Maestlin should not be unhappy, for his book would

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[1]Maestlin's algebra writings date from after 1600. Kepler felt a deficiency in advanced mathematics after leaving school and learned what he could on his own.

[2]This included checking proofs and producing tables and diagrams.

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ensure the older man immortality. Having been asked for his opinion of Kepler's work by the Senate, Maestlin wrote a letter of praise wholeheartedly recommending the publication.[1] As pointed out above, he was not averse to Kepler's aprioristic approach to Copernican astronomy but did privately frown on the employment of physical causes; this reservation was not mentioned to the Prorector, however.

The actual writing of the book required Maestlin's help as well. Kepler, having some difficulty in reconciling the distances of the planetary spheres with his a priori scheme, was forced to ask his teacher for assistance. Maestlin's answer, on 27 February 1596 (O.S.), was in the form of an appendix to the book: "Dimensiones Sphaerarum Mundi Juxta Calculum Tabularum Prutenicarum Secundum Hypotheses Copernici."[2] He also appended a new edition of Rheticus' Narratio Prima with Maestlin's corrections and preface.[3] Maestlin's insertion of this new edition was done without Kepler's knowledge. He felt it was important since the book, often referred to by Kepler, was a commentary on the more obscure passages of the Mysterium Cosmographicum and helped to clarify much of Kepler's thought.[4]

Once the work was published, Maestlin was given fifty copies of the book to dispose of, and, in appreciation for his services, Kepler sent him a costly silver cup. The cup figures in an anecdote that

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[1]Letter of 31 May 1596 (O.S.). GW XIII, No. 43, pp. 84-6.

[2]GW XIII, No. 29, pp. 56-65. Part of the MS is in the Stuttgart collection. Kepler wished Maestlin to compute the distances of the planetary spheres from the sun rather than from the centre of the earth's orbit (as had Copernicus). These calculations were difficult and time-consuming.

[3]See above, section 3.4.

[4]GW XIII, p. 95. Koestler, Sleepwalkers, p. 256, implies that Kepler (not Maestlin) added the Narratio Prima for the reasons noted.

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Maestlin related to his pupil which, incidentally, shows something of Maestlin's character. Kepler's mother had come down to Tübingen and had called on Maestlin to see about a debt of 200 florins which she thought her son had incurred. Maestlin assured her that she was mistaken and that it was he who was in debt to her son for the expensive cup. He then invited her to lunch and conversation, but Frau Kepler declined for want of time. He insisted that she at least stay to help initiate the cup, and "we nevertheless inaugurated the drinking cup as if we were fond of drinking!"[1]

No sooner had the Mysterium Cosmographicum been published than Kepler had another task for his teacher: to help persuade the duke of Württemberg that he needed a silver liquor dispenser shaped like Kepler's universe.[2] More letters passed among Graz, Tübingen, and Stuttgart to effect the fabrication of the dispensing fountain, but Maestlin eventually had to report the failure of the project. Kepler then substituted a mechanical planetarium which, like the fountain, failed to materialize.[3]

Duke Friedrich I turned to his professor of mathematics for opinions of Kepler's early works. On 12/22 March 1596 Maestlin wrote to him about Kepler's Mysterium Cosmographicum as requested, giving the book a favourable opinion.[4] Kepler had also written a tract De Natura et Significationibus Cometarum (now lost), and Friedrich had consulted

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[1]Maestlin to Kepler, 22 April 1599 (O.S.); GW XIII, No. 119, p. 328.

[2]A MS diagram of the dispenser is in the Maestlin collection in Stuttgart.

[3]The negotiations dragged on for several years. The letters of Kepler and Maestlin, and the notes of the duke are in GW XIII.

[4]GW XIII, No. 31, pp. 67-9.

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Maestlin on its worth. Maestlin's reply is also lost.[1]

A great number of letters were exchanged by the two astronomers until 1600, at which time the correspondence broke off abruptly on Maestlin's part, not to be resumed until 1605 and then only sporadically. Why the sudden change in attitude? Relations between the two were certainly cordial enough prior to 1600, while the tone of Maestlin's later letters is more reserved. During the early years, he often signed his letters to Kepler with his favourite monogram $\begin{matrix} M \\ M\ M \\ G \end{matrix}$ which stood for "Michael Maestlinus Magister Mathematicus Goeppingensis." Although this monogram appears in several of his books, it does so rarely in his correspondence. For Maestlin to have used the monogram in his letters to Kepler indicates his affection for his student.

Several reasons may explain Maestlin's sudden unilateral breaking of communication. First, his family life had become grievous, for he had lost his daughter Sabina in 1596 and his son August in 1598, and had seen his son Michael flee to the Jesuits. In his letter to Kepler concerning the death of August, we saw how heartbroken he was.[2] From these events Kepler concluded that Maestlin had ignored his letters because he was in a state of melancholy.[3]

Koestler has suggested another possibility: that Maestlin simply became frustrated by the constant "demands and badgerings" of the younger man.[4] There may be some truth in such a supposition, although why

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[1]The covering letter is extant; see GW XIII, No. 39, pp. 103-4.

[2]See above, section 1.3. The last letter was dated 9/19 October 1600; see GW XIV, No. 178, pp. 155-7.

[3]GW XIV, No. 242, p. 354.

[4]Koestler, Sleepwalkers, p. 284.

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should Maestlin suddenly become irritated with Kepler after good-naturedly writing to and helping his former pupil for so many years?

Kepler's own conclusion can be brushed aside, for, if Maestlin were suffering from a prolonged state of melancholy, his correspondence with others and possibly even his teaching would have ceased. Neither seems to have been the case. It is possible that he was depressed during much of the period, and there is evidence that he was physically ill at times after 1600, but it seems improbable that these difficulties would have resulted only in a hiatus in communication with Kepler. What may be closer to the truth is hinted at in Maestlin's first letter to Kepler at the end of his five-year silence. In it he says:

> Although for several years now, most famous man and honoured, sincerely faithful friend, I have been very tardy in writing to you, your spirit of persistence, devotion and honest love have not weakened but have become ever stronger. Although you have been carried up to such a degree and position of honour whence, if you wish, you can look down on me. . .the truth of what hindrance has held up my letters up to now, I am unwilling to examine or excuse; one thing I will take up: that I have nothing worthy to offer you, most excellent mathematician.[1]

He adds that he has no observations to communicate to Kepler because the weather has been so poor. As for Kepler's theoretical questions:

> Next, I am forced to confess that you sometimes ask about more subtle things than I am able to satisfy with my talents and knowledge. Unavoidably therefore, I have been speechless. But enough of that. God willing, I will give opinions in the future, master and most sincere friend, so that I might balance out, as much as I can, the amount that was neglected by me. I will answer concerning that which I know; what I do not know, either because of my ignorance or lack of skill, will be made known to you.[2]

On the questions raised in the Optics of Kepler, Maestlin has nothing

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[1]Letter of 28.1.1605 (O.S.); GW XV, No. 322, p. 131:1-9.

[2]Ibid., p. 132:26-32.

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to offer:

> My judgement concerning that book, which I see you desire by implication, you will await in vain because there is more subtlety contained therein than for which I have dared form an opinion. . .The most respectful and often repeated mention made of my name in that book is a testimony to your especial devotion. I fear, however, that you attribute too much to me. Would that it be, what you declare about me! Truly, I know only my modest craft. May the Lord God mercifully grant you life and vigour so that you might probe and turn up great things, useful and praiseworthy for the use of the Republic of Mathematics, and that you may be able to communicate them to us.[1]

This letter seems to be a confession that Maestlin is simply not of the same class as his student. Although Kepler's major works might have given Maestlin that impression, they could not have done so since only the Optics had been published prior to 1605; the Astronomia Nova, Kepler's most important work, did not appear until 1609. It seems to me, therefore, that the silence may have betokened more than just a feeling of inferiority on Maestlin's part.

A closer examination of the dates and topics of the last letters in 1600 will suggest a third possibility for the disruption of communication. Kepler's letters in 1600 were mostly calls for help. The Catholic counter-reformation was then sweeping Styria and, being a Protestant, Kepler was obliged to leave both his home and employ. Prior to his last letter to Kepler, Maestlin had heard from his beleaguered student on 9 September 1600 (n.s.). In this letter Kepler is desperate and even suggests that he might come to Tübingen with his family, saying that his old teacher could undoubtedly find a "small professorship" for him.[2]

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[1] GW XV, p. 132:45-7; 50; p. 133:1-5. Maestlin also mentions that his observations of the nova of 1604 have been frustrated by weather conditions and that he cannot help Kepler with his problem of Mars' motion.

[2] GW XIV, #175, pp. 150-2.

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Maestlin answered him on 9/19 October 1600, saying that he could pray for his student but nothing more.[1] This letter finally caught up with Kepler in Prague in December. Upon reading it, Kepler dispatched another plea for help to Maestlin (on 6/16 December 1600). Although he related his melancholy on hearing that his teacher could do nothing to help, he also mentioned that he was to work with Tycho Brahe (who had been named Imperial Mathematician to Rudolf II).[2] This letter elicited no response from Maestlin, nor did any of the ensuing ones.[3] It appears that Maestlin maintained contact while Kepler had no position or prospects and severed ties when he knew that the younger man had come under the protection of Tycho in Prague. That Tycho was the greatest living astronomer and in the employ of the emperor himself must have been enough to convince the Tübingen professor that his services were no longer required. Seen in this light, Koestler's suggestion is more plausible.

This does not necessarily mean that Maestlin had hostile intentions but rather that, on learning of Kepler's good fortune (or to Maestlin it must have seemed so), he knew that his position in his pupil's life was no longer the same. Feeling he had done enough for his student over the years, he washed his hands of Kepler's troubles, letting Tycho inherit them. That Kepler was now associated with the Imperial Mathematician would have emphasized Kepler's superiority in Maestlin's mind. When, after Tycho's death in 1601, Kepler himself became Imperial Mathematician, Maestlin was no more inclined to answer his letters. His 1605 letter

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[1] GW XIV, #178, pp. 155-7.

[2] Ibid., #180, pp. 158-9.

[3] Kepler wrote at least four times between 1600 and 1603, mostly in the period of 1600-01.

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explicitly states the thoughts that must have been in his mind in some part from 1600.

Thereafter, Maestlin wrote only occasionally to Kepler, and in 1620 all correspondence between the two seems to have ceased.[1] No doubt both knew something of the other's activities through third parties such as Schickard in Tübingen. From 1600, when Maestlin first stopped communicating, Kepler continued sending requests for assistance or counsel, most of which Maestlin ignored. He also sent copies of his works, but, as Maestlin states in 1605, they went mostly unread or unappreciated. On several occasions Kepler returned to Tübingen and stayed with his teacher. He was last there in the spring of 1625 when he consulted Maestlin's library in preparation for his Tabulae Rudolphinae.[2] Of his last visit to his 75-year-old mentor, Kepler related to Crüger in Dantzig (letter of 1/May 1626) that he had spoken with both Schickard and Maestlin on the mean motions of planets and other astronomical matters, saying "Truly, that one [Maestlin], now worn out by age is prompt, sharp, but, distracted by a most laborious profession, is presently contributing nothing to the art which is up to measure."[3]

That Maestlin had a great influence upon Kepler, particularly in the latter's younger years, is evident throughout Kepler's earlier writings. Maestlin is mentioned often in his books, especially in those concerned with lunar astronomy. Likewise, many allusions to him are

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[1]The last letter is from Kepler, dated 19 June 1620 (n.s.), in which he discusses logarithms, politics, his new lunar theory, and Maestlin's observations of the lunar eclipse of 20 December 1620. GW XVIII, #884.

[2]Letter to Bernegger of 20/30 June 1625, GW XVIII, #1010, p. 237.

[3]Ibid., #1026, p. 262:20-22.

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found in Kepler's earlier correspondence with others. In just what ways, then, did he influence Kepler? We may begin by enumerating the subjects cherished by Kepler that Maestlin did not influence. It is obvious to me that Maestlin was not the source of Kepler's life-long search for the harmonies in the universe. It is true that the Tübingen astronomer agreed with Kepler's "discovery" of the a priori arrangement of the planets announced in 1596 and re-affirmed that agreement in 1613.[1]

But by the time of publication of Kepler's opus magnus, the Harmonices Mundi (1617, 1621), Maestlin was no longer commenting on his works (even assuming he read them). Thus, we cannot tell what he thought of Kepler's conclusions on the matter. While agreeing with Kepler about his early conceptions, there is nothing in Maestlin's writings or letters to suggest that the search for cosmic harmony was of any importance to him or that he even saw any sense in such an undertaking. As we saw above,[2] he had no faith in astrology and refused to cast horoscopes, which Kepler did although he felt astrology could be placed on a scientific basis. While it is certain that Kepler did not receive any encouragement in this art from his teacher, it is also improbable that he learned anything of it from him.[3]

A number of Kepler's interests do coincide with those of Maestlin, however. The mathematics taught to Kepler by Maestlin was elementary,

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[1]Letter to Kepler, 25 June 1613 (o.s.); GW XVII, #660, p. 67.

[2]See above, section 3.4.

[3]Maestlin did, in fact, influence Kepler in the realm of astrology. During the time Kepler studied at Tübingen, he was continually subjected to Maestlin's discouragement of astrological activities and his emphasis upon the strictly scientific aspects of astronomy. Although Kepler had a propensity for the mystical mode of thought, his more rational view of astrology may well have developed as a result of Maestlin's attitude.

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and it is probably significant that references to Maestlin in his mathematical works are very few. Granted that his accomplishments in mathematics were his own apart from the elements taught him by Maestlin, Kepler could not have helped absorbing some of his teacher's enthusiasm for the subject. Maestlin's ability to excite others about mathematics is unquestionable, for other students of his maintained an interest in that subject long after they had graduated.[1]

It is in astronomy that Maestlin's influence primarily lies. Kepler had entered Tübingen for a church career. Maestlin's preparation, however, enabled Kepler to teach mathematics and astronomy upon graduation, and within only a few years he was able to publish an original book on astronomy. Whether Kepler joined Maestlin in the Schloß or at his home for observing sessions is unknown, but the fact that Kepler observed on his own after his departure from Tübingen suggests that Maestlin had taught him at least the rudiments of observational technique. Needless to say, Kepler's grasp of basic astronomy was due to Maestlin's Epitome and lectures.

It is with the Copernican doctrine that Kepler's debt to Maestlin is the greatest. I have already discussed how Maestlin came to adopt the heliocentric view of the world, and it remains to be shown how this view was passed to Kepler. He says in his preface to the Mysterium Cosmographicum that Maestlin "in his lectures used to make mention of Copernicus very frequently."[2] Maestlin's textbook also referred to Copernicus, but this would hardly have converted the average student. Although Maestlin may have tutored Kepler, there is no evidence to

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[1]Examples being Schickard, Andreae, Mögling, etc.

[2]GW I, p. 9.

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support the possibility that such sessions took place.[1]

Kepler does give some indication in the Mysterium Cosmographicum of what reasons led him to adopt Copernicanism: first, the hypotheses saved the phenomena; and second, the heliocentric theory was simple and unified. There was a third reason, however, which came from his teacher:

> And not, however, blindly, nor without my most venerable teacher, Maestlin, the most famous authority on mathematics, was I led to embrace this school of thought. Now he, although he was my first leader and guide, not only in other ways but also especially to this way of philosophizing [led me] and he ought to be rightfully numbered in the first place . . .[2]

Maestlin had discovered that the comet of 1577 followed the motions of Venus as Copernicus described them. That reason alone, says Kepler, would be enough to convince one of the Copernican theory.[3] He may well have read Maestlin's Observatio & Demonstratio and been convinced in the same way that his teacher had.[4] He must have done additional reading after leaving Tübingen, for he was a thoroughgoing Copernican by 1596.

Kepler, like so many scholars of the sixteenth and seventeenth centuries, had a passion for Biblical chronology. Maestlin was also deeply engrossed in the subject, and in the years following Kepler's departure for Graz, the two exchanged chronological problems -- problems often calling for the use of astronomy. Kepler might have been drawn independently to chronology, but since Maestlin was already involved

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[1]Curiously, Caspar (Kepler, p. 49) quotes Kepler's statement from the Mysterium Cosmographicum and yet maintains that Maestlin taught only orthodox astronomy publicly, reserving Copernicanism for an intimate circle of students.

[2]GW I, p. 16:39-40; 17:1-3.

[3]Ibid., p. 17.

[4]However, in his notes to the second edition of the Mysterium Cosmographicum, Kepler says " . . . Maestlin later knew the conclusion was not necessary . . . Brahe, in his book on the comet, compared his hypothesis with Maestlin's and refuted it." GW VIII, p. 40.

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in the discipline and his manuscripts were at Kepler's disposal, he is a likely candidate for the early source of Kepler's chronological knowledge and enthusiasm. That Andreae, Hafenreffer, and Herwart were all influenced by and interested in Maestlin's chronological work also supports such a view.

As said above, I think Maestlin is not responsible for that facet of Kepler's thought which tended toward the mystical, neo-Platonic and Neo-Pythagorean speculations that typify his writings to the end. In more mechanical terms, however, Kepler did turn to Maestlin for his pedagogic model: that is, when he decided to write his Epitome of Copernican Astronomy, he consciously borrowed the format of his teacher's own textbook, the Epitome Astronomiae. As Maestlin's method of presentation was relatively new for astronomical books in the sixteenth century, it is obvious that Kepler decided Maestlin's format was the best for his purposes. In a letter to Nicholas Vicke of July 1611, Kepler speaks of " . . . my book concerning the principles of astronomy, which I produced in imitation of the first book on the spheres by Maestlin."[1] Maestlin himself, writing to Kepler on 21 September 1616 (o.s.), agrees that such an epitome is a good idea.[2]

In their respective views of scientific method, Kepler and Maestlin were worlds apart. The older man became more conservative with age and often criticized Kepler's flights of fancy and his appeal to physical causes. He did so not for the reasons we would give today (Maestlin was, after all, a child of the Renaissance) but because he championed the classical method of astronomical reasoning with geometry

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[1] GW XVI, No. 619, p. 389. While Kepler speaks as if he has finished the work, he did not publish the last part until 1621.

[2] GW XVII, No. 744, p. 187.

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and felt that Kepler was using inappropriate methods. Maestlin could not break from tradition in this way, but Kepler could.

To review their relationship: even after Maestlin dropped the correspondence in 1600, Kepler retained his love and respect for him. Maestlin even figures in Kepler's science-fiction work, the Somnium, for the Daemon of Levania, in explaining the way to travel to his island home, says:

> We admit to this company nobody who is lethargic, fat, or tender. On the contrary, we choose those who spend their time in the constant practise of horsemanship or often sail to the Indies, inured to subsisting on hardtack, garlic, dried fish, and unappetizing victuals.[1]

In his notes Kepler adds:

> I was thinking of the epigram which I once jokingly aimed at the bodily build of Maestlin, who was then my teacher: "The lighter the weight a man carries on his delicate bones/ the more swiftly he flies to the heavenly homes." The fine delicacy of Maestlin's mind is well known.[2]

Contemporary portraits of Maestlin explain this jocular aside.

Throughout the years, Kepler addressed many queries, problems, and demands to Maestlin which, before 1600, he cheerfully met or answered. Keeping in mind the fact that Maestlin was a generous and thoughtful man, why did he help his student only in scientific affairs but not in his private life when Kepler was in deep trouble? It was for good reason that he could not: a position at Tübingen was out of the question, not only because of the closeness of the academic community there, as Caspar has suggested,[3] but more importantly for religious

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[1]Kepler, Somnium, p. 15.

[2]Ibid., pp. 64-5.

[3]Caspar, Kepler, p. 103; the closeness of community is evident from the interrelations of the academics. See above, section 1.4.

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reasons. Kepler was considered a crypto-Calvinist by the Württemberg church authorities, and he did indeed deny the doctrine of "ubiquity," i.e. the omnipresence of both the body and spirit of Christ. Maestlin, being aware of Kepler's religious deviation from Lutheran orthodoxy, must have known that he could not in good conscience subscribe to the Formula of Concord. Being orthodox had gained Maestlin two academic chairs, and he was well aware of the religious problem. It is likely that Kepler would have been turned away by the Consistory even had he subscribed to the Formula.[1] This factor cannot be over-emphasized, for religious orthodoxy was firmly entrenched in Württemberg and religious freedom not easily tolerated.

Yet, we must conclude that in Kepler's formative years Maestlin offered invaluable assistance and support, and, without him, Kepler would have had an even more difficult path to follow. Maestlin's position in Kepler's life is well summarized by Caspar:

> There is before all Michael Mästlin, bright, wary, secure in his job and his life, proud of his old student, always ready to smooth the way and to comply with the many questions and wishes of the young friend.[2]

4.2 Maestlin's Students, Friends, and Colleagues

The number of students who were given instruction in mathematics and astronomy by Maestlin undoubtedly numbered in the hundreds during his forty-seven years at Tübingen. Although they were overshadowed by Kepler, a number of Maestlin's students attained some stature in the history of science and mathematics. Foremost among his other students was Wilhelm Schickard. Schickard, like both Maestlin and Kepler, was a

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[1] Caspar, Kepler, p. 213.

[2] GW XIII, p. 373.

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Swabian, born in 1592 in Herrenberg. Like his predecessors, he was educated in the klosterschule before matriculating at Tübingen. He probably attained his master's degree in 1613 and was a repetent in theology in 1613 or 1614; in 1614 he became a deacon in Nürtingen.[1] Schickard returned to his university in 1619 to become Professor of Oriental Languages (primarily teaching Hebrew). It appears that he also aided Maestlin, now in his seventies, in mathematics and astronomy.[2] On Maestlin's death, Schickard was assigned the lectures in astronomy along with those in language. He and his entire family perished in the plague that reached Tübingen in 1635.

Schickard had a wide range of scientific interests and studied astronomy, meteorology, mathematics, optics, and mechanics.[3] He corresponded with Kepler on a number of these topics and published, among other works, Anemographia seu discursus philosophicus de ventis (Tübingen, 1631) on meteorology and Tractatus de Mercurio sub Sole et aliis novitatibus uranicis (Tübingen, 1634) on astronomy. An early convert to the use of logarithms, Schickard not only corresponded with Kepler on the subject but rescued his friend's manuscript from Maestlin's neglectful hands and saw it through publication.[4] An interesting byproduct of Schickard's mathematical interest was a calculating machine which he

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[1] S. Günther, "Wilhelm Schickard," ADB XXXI, p. 174.

[2] Ibid.

[3] Schickard wrote on the fireball observed in Tübingen in November 1623 and described an observing instrument he had invented: Astroscopium pro facillima stellarum cognitione excogitatum et commentariolo illustratum (1623; second edition 1698). Schickard was also a geographer and wrote a Kurze Anweisung, wie künstliche Landtafel aus rechtem Grund zu machen (Tübingen, 1669).

[4] See above, section 2.4.

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built in 1624, nearly twenty years before Pascal constructed one. The machine, described to Kepler in letters of 20/30 September 1623 and 25 February 1624 (o.s.), could add, subtract, multiply, and divide.[1] Schickard evidently had one built which subsequently perished in a fire.[2]

Schickard informed Kepler of Maestlin's activities throughout the period after 1620 when Kepler and his old teacher had ceased communication. That he aided Maestlin in the latter's professorial duties suggests that Maestlin held his student in esteem. Kepler, likewise, thought highly of his friend and said in a letter to Crüger in 1624 that "Schickard, Professor of Oriental Languages, philosophizes by genius and by hand."[3]

From the sons of faculty colleagues, Maestlin had two outstanding pupils -- Andreae and Hafenreffer. Johann Valentin Andreae, grandson of the old Tübingen chancellor, was born in 1586 and entered the university in 1601, studying theology with Matthias Hafenreffer and mathematics and astronomy with Maestlin. He took his B.A. in 1603 and his M.A. two years later. In 1614, he published a Collectanea Mathematica which represented some of the ideas of his teacher.[4] Andreae became a parson in Vaihingen (1614-1620) and married Agnes Grüninger, Maestlin's niece. Like his grandfather, he was primarily interested in theology but also entertained an interest in Biblical chronology; in 1642, he published Maestlin's

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[1] GW XVIII, #962, p. 142, and GW XVIII, #975, p. 170 with a sketch.

[2] Details of the machine are in B. von Freytag-Löringhoff, "Über die erste Rechenmaschine," Physikalische Blätter (1958), pp. 361-5.

[3] GW XVIII, #974, p. 168:313-14.

[4] Hans Aarsleff, "Johann Valentin Andreae," DSB I, p. 159.

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Synopsis Chronologiae Sacrae.[1] Andreae died in 1654.

Samuel Hafenreffer was the son of Maestlin's friend Matthias Hafenreffer, professor of theology at Tübingen. He received his B.A. from Tübingen in 1601 and his M.A. in 1604, having studied with Maestlin in the intervening period. After travelling and teaching for a number of years, the younger Hafenreffer returned home and studied medicine. He received his M.D. in 1614 and eventually became professor of medicine at Tübingen in 1648.[2] Hafenreffer, like Andreae, was not an astronomer or mathematician but maintained a lifelong interest in those subjects. He was involved in a disputation on the motions of the planets, defending Maestlin's theses in public.[3] Although his collaboration with Maestlin ended on his departure from the university, Hafenreffer did not forget his teacher. Having obtained the manuscript of Maestlin's unpublished Chronologicae Theses et Tabulae Breves, he printed the work in 1641.[4]

Three other students with interests in mathematics and astronomy should be noted briefly. Maestlin maintained correspondence with Georg Galgemair who had studied under Maestlin and possibly with Apian.[5] Galgemair took his B.A. in either 1583 or 1584 and his M.A. in 1585.[6] In

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[1]See section 2.5. Andreae's utopian Reipublicae christianopolis descriptio (1619) was much akin to Bacon's New Atlantis. Andreae also wrote several Rosicrucian works, one of which dealt with chemistry.

[2]Hafenreffer published a number of works on medicine but none on mathematics or astronomy.

[3]See above, section 3.1.

[4]See above, section 2.5.

[5]As Apian was in Tübingen until 1584, Galgemair may have heard his lectures. This is claimed by A.G. Kästner, Geschichte der Mathematik, 4 vols. (Göttingen: Rosenbursch, 1796-1800), III, p. 347. [Hereinafter cited as Kästner, Geschichte.] In his letters, Galgemair refers to Maestlin as "praeceptor," however.

[6]Hermelink, Matrikeln, I, p. 620 and 620n.

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1589 he wrote to Maestlin advising him that a copy of Clavius' Gnomics, which he might be interested in seeing, had arrived.[1] Besides mathematical topics (Maestlin sent Galgemair some geometrical demonstrations and disputations in 1593),[2] the two exchanged astronomical observations, particularly of lunar eclipses.[3]

One of Kepler's classmates, Christopher Besold (1577-1638), who later became an outstanding jurist and professor of law at Tübingen, also studied under Maestlin. Although he is not otherwise known for an interest in astronomy, Besold figures in Kepler's Somnium and the latter's youthful interest in lunar astronomy.[4]

Another student and correspondent of Maestlin was Daniel Mögling, a theology professor at Tübingen. He was much interested in algebra and sent demonstrations to his teacher in the 1620's.[5] Several letters of Mögling are in the Wolfenbüttel collection, but Maestlin's responses (if he did indeed respond) are lost.

Among the students of Maestlin, Steiff[6] has included Johann

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[1]Cod. Math. 2° 14.

[2]Cod. Guelf. 15.3 Aug. 2°.

[3]Galgemair was primarily interested in the proportional compass and wrote several works on it including: Centriloquium circini proportionum. Ein Newer Proportional Cirkel, von vier, fünff, sechs, oder mehr Spitzen. (Nürnberg, 1626); Kurtzer und Gründtlicher Underricht wie der künstliche Proportional-Circul auszutheilen und aufzuzeichen sey (Langingen, 1610) and a larger edition published at Ulm in 1615; Inventum P. Apiani; das ist Beschreibung eines geometrischen Instruments (Augsburg, 1616). See also, Kästner, Geschichte, III, p. 343.

[4]See Kepler, Somnium, p. 32.

[5]Mögling wrote several medical works and presided over disputations. His chief scientific work was a translation of Guido Ubaldo del Monte's Mechanicorum Liber (1577), along with Baldi's comments on pseudo-Aristotle's Questions of Mechanics, in Mechanischer Kunst-Kammer (Frankfurt, 1629).

[6]Steiff, "Michael Mästlin," p. 63.

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Faulhaber and Herwart von Hohenburg. Although neither formally studied with Maestlin, both corresponded with him.[1] Johann Faulhaber, the mathematician and engineer of Ulm, does not seem to have had a university education. Son of a weaver, he was proficient enough in practical mathematics to become city rechenmeister at Ulm.[2] As a mathematics teacher, Faulhaber gained a circle of disciples in Germany and Switzerland; as an engineer, he devised the city fortifications at Ulm.[3] Maestlin and Faulhaber corresponded on mathematical and astronomical problems; one letter from the former to the latter survives in Tübingen in which Maestlin refuses to send his friend an astrological prediction concerning the great comet of 1618 for "I am not an astrologer."[4] In Wolfenbüttel there is a set of geometrical problems written for "my friend Johann Faulhaber."[5] It is unlikely that Maestlin corresponded with Faulhaber on the latter's interests in numerology, prophecy, and alchemy, being subjects outside

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[1]There was a Samuel Faulhaber from Ulm who took his B.A. in 1591. In the matriculation records it is recorded: "Locum quartum decimum inter magistros habuisset, sed 2 Aug. in Patria mortuus est, bonus et doctus adolescens." Hermelink, Matrikeln, I, p. 685n. Perhaps this was a close relative of Johann.

[2]Höchstetter, "Johann Faulhaber," ADB VI, pp. 581-3. Apart from his mystical interests, Faulhaber published several works of scientific note including: Ingenieur-Schul (Frankfurt, 1630 and later editions), a popular text on practical problems; Mathematici Tractatus nuper Germaniae edita: continentes, prior novas geometricas et opticas aliquot singularium Instrumenti (Frankfurt, 1610); Ein Mathematische newe Invention, einer sehr nutzlichen und geschmeidigen Hauss oder Handmühlen, etc. (Augsburg, 1631). Faulhaber was one of the first to write on logarithms, in his Ingenieur-Schul, and had a great interest in the proportional compass.

[3]Caspar, Kepler, p. 335.

[4]UT MS. Mi XII. 27[b]. Dated 18 January 1619. Faulhaber published a tract on the comet of 1618, his Fama Syderea Nova (Nürnberg, 1618).

[5]Cod. Guelf. 15.3 Aug. 2°.

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the realm of his more scientific outlook. Faulhaber died in 1635, carried off by the same plague that killed Schickard and probably Maestlin's son Gottfried.

Remembered as a friend and correspondent of Kepler, Hans Geörg Herwart von Hohenburg, the Bavarian chancellor, wrote to Maestlin but probably did not study with him despite Steiff's claim.[1] Herwart came from an illustrious Augsburg family, his mother being a Welser.[2] He attended the university in Ingolstadt in his native Bavaria in 1574 and, during his years as chancellor, entertained a number of scientific hobbies.[3] One letter from Herwart to Maestlin survives in Stuttgart, dated 28 May 1602 (N.S.). In the letter, which is only a paragraph long, he comments on the comet of that year and asks for Maestlin's observations.[4] Zinner[5] lists one letter from Maestlin to Herwart. As his letters to Kepler attest, Herwart was well-versed in scientific and mathematical subjects. Another great interest of his was Biblical chronology, on which he published in 1612 his Novae, verae et exacte ad calculum Astronomicum revocatae chronologiae et capita praecipua which includes problems posed by Maestlin and transmitted to Herwart via Kepler and possibly by Maestlin himself.

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[1]In the matriculation records of Tübingen there are Antonius and Hieronymous Hörwardt from Augsburg, but no Hans Geörg.

[2]Eisenhardt, "Hans Georg Hoerwarth von Hohenburg," ADB XIII, p.170. The Welsers were a rich and powerful family in Augsburg. Galileo dedicated his three letters on sunspots to Marcus Welser, a Duumvir of the city and an Imperial Councillor.

[3]Herwart published mathematical tables, his Tabulae arithmeticae universales (Ingolstadt, 1611).

[4]Cod. Math. 2° 14.

[5]Zinner, Verzeichnis, p. 218, lists a letter in Munich, Mü 2° 692. 163. I have not seen this letter.

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Maestlin was associated with two controversial figures of the time: one was a colleague at Tübingen, Nicodemus Frischlin, and the other a Tübingen graduate, Helisäus Röslin. Frischlin was born in Balingen in Württemberg. After studying at the same klosterschule as Maestlin later did (Königsbronn), he came, in 1563, to Tübingen, where he was a classmate of Röslin's. He became professor of poetry and history at Tübingen and held the post when Maestlin arrived in 1568. Being a turbulent man, he was often involved in polemics of varied natures. He wrote against the logic of Ramus and became embroiled in an argument with another colleague, Martin Crusius. Crusius charged him with wanting to rid the schools of Melanchthon's works, a charge which Frischlin could not understand as Tübingen had banned the use of the Rhetoric, Dialectic, Initia Doctrinae Physicae atque Ethicae, as well as other works of the Tübingen-educated reformer.[1]

Frischlin was interested in astronomy and published in 1573 a work on the nova of the preceeding year. This work, Consideratio novae stellae, contained Maestlin's own tract on the New Star. Frischlin was a harsh critic of astrology, his chief attack being his De Astronomicae artis cum doctrina coelesti et naturali philosophia congruentia of 1586. Maestlin wrote a critique on this work.[2]

On leaving Tübingen, Frischlin began a life of peregrination

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[1] Details of the controversy are in Thorndike, History of Magic, V, p. 380.

[2] I have not located the work. It was in Tübingen, but the library there seems to no longer possess it. It is summarized briefly in David Strauß, Leben und Schriften des Dichters und Philologen Nicodemus Frischlin (Frankfurt: Litterarische Anstalt, 1855), pp. 328ff. [Hereinafter cited as Strauß, Nicodemus Frischlin]. The De Astronomicae artis was his only scientific work and was a collection of lectures delivered at Tübingen after Apian had been removed from his chair.

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and controversy. He met an untimely end trying to escape from prison in Württemberg in 1590. Maestlin noted in 1609:

> Frischlin the poet was quite notable, but his nature was quite stormy and the conduct of his life was intolerable to the whole university. . .he quit the place and transferred to the school in Graz.[1]

Röslin was involved in controversies as well but led a less turbulent life than his classmate Frischlin. Helisäus Röslin was born in Pleiningen, Württemberg and studied in Stuttgart and Tübingen, where he took his M.D. in 1569. He studied astronomy under Samuel Eisenmenger (Siderocrates), Apian's predecessor. Although Röslin was primarily a medical doctor, his studies in astronomy and chronology brought him to the attention of Maestlin and Kepler. In his work on the comet of 1577,[2] he claims to have discovered a special sphere for comets and was one of the few astronomers to hold that the comet was supra-lunar. Röslin did not accept the Copernican doctrine but constructed a world system on the same model as Tycho's, which led the latter to attack him for plagiarism.

In 1609 he published his chief work on chronology, his Discourse,[3] which prompted Kepler's Antwort auff Röslini Diskurs of the same year. Since Röslin was addicted to astrology, Kepler attacked his views, giving his own thoughts on what astrology should accomplish while defending several of Maestlin's chronological propositions. Maestlin was happy to hear that Kepler was going to reply to Röslin's work, the Prodromus

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[1] Cod. Guelf. 15.3 Aug. 2°.

[2] Theoria Nova Coelestium METEΩPΩN. For details, see Hellman, Comet of 1577, pp. 157ff.

[3] Historischer, Politischer, und Astronomischer Naturlicher Discurs von heutiger Zeit Beschaffenheit, Wesen und Standt der Christenheit (1609).

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Dissertationum Chronologicarum of 1612, for he had wanted to reply but had had no time for the task.[1]

Röslin and Maestlin corresponded intermittently, and several of Röslin's (practically illegible) letters are in Wolfenbüttel and Stuttgart. In these letters, he primarily speaks of the comet of 1577 and the Tycho-Raimers controversy on the system of the world.[2] One of his letters was published in Maestlin's Ephemerides Novae. Dated 18 October 1578, the letter praises Maestlin's work on the comet of 1577. Röslin accepts Maestlin's corrections, saying:

> In the meantime I won't deny that anything can happen with peculiar comets, such as being nearer or farther from the earth or being placed in any of the celestial spheres, just as, I judge, you have named the true orbit of our comet; and I reckon the discovery should be ascribed to you for no one, excepting you, has discovered it.[3]

Although Maestlin didn't think his friend to be prudent,[4] he nevertheless was sorry to hear that he had died in 1616 without being within the fold of true religion.[5] Maestlin admired Röslin but felt

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[1] GW XVII, No. 651. p. 54.

[2] Röslin's system was outlined in his De Opere Dei Creationis of 1597. Röslin did not admit the motion of the earth, which Raimers suggested in his Fundamentum Astronomicum of 1588, which Röslin read. Since Tycho's system was published in 1588 as well, he immediately assumed that Raimers had stolen his own idea. Röslin's 1597 pronouncement was simply another case of plagiarism as far as Tycho was concerned. In fact, there were a number of world systems similar to Tycho's in that period. See Christine Jones, Geo-Heliocentric World Systems in the Late Sixteenth and Seventeenth Centuries. (Ph.D. thesis, Cambridge University, 1964.)

[3] Letter to Maestlin in: Ephemerides Novae (1580).

[4] "Der gutt Mann meinets gutt, sed anne omnia satis prudenter?" GW XVII, No. 651, p. 54.

[5] GW XVII, No. 744, p. 188. Röslin adhered to Schwenkfeldianism.

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that:

> When he conceives an opinion in his mind, he holds on to it by the teeth, not having sufficient reasons for it as he should nor does he compare opinions with others.[1]

The greater portion of Maestlin's correspondence was with his friends and colleagues in Tübingen, Heidelberg, and the immediate area.[2] With his friend Johann Weidner, rector of the school in Schwäbische Hall, Maestlin exchanged letters[3] detailing the vicissitudes of Weidner's former students Jacob Tonsor (a relative of Maestlin's) and David Stadmann (a relative of Weidner's). Stadmann was all Maestlin could wish in a pupil: he was pious, intelligent, hard-working, and modest. But Tonsor, because of family troubles, illness, and poverty, was making very slow progress. Maestlin interceded for his relative in a letter of 11 May 1586 (O.S.):

> . . .I ask and implore you, that the patrons of his studies, the Lord Senators of Hall. . .might wish to contribute something of a subsidy towards the promotion of my relative's studies; without it, because of adversity, misery, and most perilous conditions, he cannot at last follow his studies to the end.[4]

Besides detailing Tonsor's woes, he told Weidner that he would send him a copy of the Außführlicher Bericht for his perusal. In a letter of 20 March 1590 (O.S.), he gave some observations of the comet of that year (first seen by him on 24 February) and chasms seen on 26/27 February

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[1] GW XVII, No. 651, p. 54.

[2] The majority of the correspondence is in WLB Cod. Math. 2° 14 and HAB Cod. Guelf. 15.3 Aug. 2°.

[3] WLB Cod. Hist. 2° 603.

[4] Ibid., no. 338; Tonsor matriculated at Tübingen on 23.6.1584 (O.S.) but was unable to pass his B.A. examination until September 1585. He did not complete an M.A. Hermelink, Matrikeln, I, p. 625.

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of that year. He also mentioned halos about the moon observed on 1 and 10 March.[1] His letters to Weidner typify much of his correspondence.

From Heidelberg, the doctor and natural historian Georg Marius wrote to Maestlin on mathematics and chronology. In his letters[2] his reference to Maestlin as "Archimedes" indicates his appreciation of Maestlin's mathematical talents. His letters suggest, however, that his friend in Tübingen was remiss in answering his queries promptly. Among the numerous letters are several to and from Maestlin's colleagues: Liebler, Planer, Brenz, Pappius, Gerlach, Schäfer, Ziegler, Hamberger, and others. He also maintained contact with his fathers-in-law Erasmus Grüninger and Georg Burckhardt, as well as his brother-in-law Erasmus Grüninger the Younger. These letters concern local events and university affairs. Maestlin kept informed of the activities of his colleagues and relayed information to mutual friends. After leaving Heidelberg, he maintained contact with several friends he had made while teaching there. To those friends and acquaintances interested in mathematics or astronomy, he sent proofs and observations, and they reciprocated with like material. Maestlin was deeply involved in the life of his academy, noting the number of candidates for degrees, promotions and departures of colleagues, disputations, etc. These interests are characteristic of his correspondence. Indeed, his scientific correspondence comprises a far smaller percentage of his extant letters. Practically without exception, his letters went out to Germans; except for Tycho and Kepler, his friends and correspondents were academics like himself or lesser-known scientists.

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[1] Cod. Hist. 2° 603,579.

[2] Cod. Math. 2° 14.

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4.3 Maestlin's Contemporaries and Near-Contemporaries: Their Opinions of his Astronomical Work

In this section I will not attempt an exhaustive survey of the late sixteenth and early seventeenth century astronomical literature since mention of Maestlin for the large number of citations would be quite extensive. Instead, I will discuss only a number of representative opinions from Maestlin's German, Italian, French and English contemporaries or near-contemporaries, particularly those of better-known astronomical writers such as Tycho, Galileo, Hagecius, Riccioli, etc. The important facet I wish to emphasize is the manner in which his contemporaries learned of Maestlin and his researches.

An important scientific correspondent of Maestlin was Tycho.[1] An excellent observational astronomer himself, Tycho quickly saw the younger man's merit as an observer. Maestlin's observations of the new star of 1572 brought him to Tycho's attention, for Maestlin had come to the same conclusions as had Tycho: the new star had no parallax and was, therefore, in the celestial regions. As we saw above,[2] Tycho included Maestlin's short tract on the nova in his Progymnasmata and praised his work even though Maestlin had used inadequate instruments. Considering Tycho's character, however, it is conceivable that his praise for Maestlin was linked with the fact that they had reached the same conclusion rather than because of Maestlin's observational prowess. The comet of 1577 offered another opportunity for Tycho to examine Maestlin's astronomical thought: excepting Maestlin's embracing of Copernicanism, both astronomers agreed on the nature of the comet. Tycho gave a synopsis and

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[1] No biographical or bibliographical detail should be necessary for Tycho. Dreyer and Norlind should be consulted.

[2] Section 3.2.

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analysis of Maestlin's Observatio & Demonstratio in his own work of 1588 in which he said that, while he could not agree with the observational data, he praised Maestlin's conclusion that the comet was supralunar:

> Indeed, among the writings which have come into my hands by those who have produced opinions on that comet, no one has produced so erudite and ingenious a work, no one has given anything so agreeable and probable . . . than M. Michael Maestlin, who at that time was deacon in the village of Backnang, but now, so I understand, has become professor of Mathematics at the University of Tübingen; . . . his exceptional study is estimated by me to be especially commendable.[1]

Because of this, Tycho said he would spend more time on Maestlin's work.

Thaddaeus Hagecius (ca. 1525-1600) was particularly opposed to Maestlin's conclusions and attacked him in letters to Tycho.[2] Answering him on 1 November 1589, Tycho said that he would not defend Maestlin out of friendship since he did not even know him, nor had he received any letters from him. He also said that, if he were to choose the foremost astronomer in Germany, he would not know whether to place Maestlin or Praetorius first, but the former was certainly very learned and ingenious. Where Hagecius felt that the astronomer could not assign a comet to a specific orbit (as had both Tycho and Maestlin), Tycho replied that:

> Indeed, I admit that the particular motion of the most rare and unique comets relate to the revolution of the entire heavens, and the sun does not always provide a centre as it does for the rest of the planets,[3] so deviations from it will not everywhere show exactly similar laws, like the moon does not since it observes its motion principally about the earth. But yet, it does not follow that it is utterly impossible to somehow reduce the motions of comets to a rule through a convenient

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[1]Tycho, Op. Om. IV, 207:34-41; 208:1.

[2]Reference below, p.p. 188-9.

[3]Tycho's world-system refers the primary planetary motions to the sun which, in turn, revolves about the earth. The moon is, of course, the exception.

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hypothesis.[1]

Just as the centre of a circle can be found from a portion of the circumference, so can the orbit of a comet be found from only a portion of its circuit. Tycho admits this is not a simple matter but that it is not impossible.

He defends his own, Maestlin's, and others' discovery that the comet had no parallax. Admitting that many had discovered a parallax, Tycho argues that they were misled by the daily motion of the comet. Parallaxes, indeed, are difficult to discover accurately.

While he agrees that Maestlin's assignment of an orbit for the comet was ingenious, he nevertheless found it to be incorrect. Tycho had observed the comet on 26 January 1578 and noted that its position was 3¼ degrees different from that calculated by Maestlin (who had last observed it on 6 January). Because of this discrepancy, Tycho believed that the Tübingen astronomer had missed the mark.[2]

As for Hagecius' detailed remarks on Maestlin, Tycho points him to the analysis provided in his 1588 work. Tycho's praise for Maestlin was not blind, for, as he tells Hagecius, "I have not rejected all the claims you make against Maestlin, but I made note of those which are seen to deserve well-founded reprehension . . ."[3]

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[1]Tycho, Op. Om. VII, p. 206:40-42; 207:1-4.

[2]J.B. Delambre rightly points out, however, that: "Tycho chooses, for example, his observations of January 26, 14 days after Maestlin said it disappeared. It is an excellent means for proving the hypothesis; but if someone had seen the comet fourteen days after Tycho, probably his orbit would have ceased approaching the observations, because he would not have modified the same observations. His calculation proved, then, against Maestlin and signified nothing in favour of his own hypothesis." Histoire de l'astronomie Moderne, I, p. 225.

[3]Tycho, Op. Om. VII, p. 212:9-11.

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In the summer of 1588, Tycho sent a copy of his new work to Maestlin via his assistant Gellius Sascerides and included a dedication and notes.[1] There are no letters from Maestlin to Tycho that I know of, although he may have written to him after 1589.[2] In Tycho's correspondence, only one letter to Maestlin is extant, that of 21 April 1598.[3] There had been no contact between the two for ten years, but each had seen the other's work. In this letter, he was primarily concerned with opposing the views held by Kepler and Maestlin which he had seen in the Mysterium Cosmographicum.[4]

Tycho rarely mentions Maestlin in his correspondence, but when mention does occur, it is usually complimentary. Writing to Hieronymous Wolf in 1579, Tycho reported that Maestlin had observed the comet of 1577 and had arrived at the truth by diligence and mathematical demonstration, adding:

> I have no doubt that if he were supplied with great and exquisitely constructed metal instruments, he would do exceptionally well at restoring and correcting the motions of the heavenly bodies from observations.[5]

Tycho also possessed a number of books by Maestlin in his library. Prandtl records only the Alterum Examen,[6] but Norlind has added several others.[7] Tycho had received the Außführlicher und Gründtlicher Bericht

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[1]Dreyer, Tycho Brahe, p. 181, claims a letter was included.

[2]Writing to Hagecius in 1589, Tycho says that he has not yet received any letters from Maestlin. Tycho, Op. Om. VII, p.205.

[3]Ibid., VIII, pp. 52-55.

[4]See above, section 3.4.

[5]Tycho, Op. Om. VII, p. 52.

[6]W. Prandtl, Die Bibliothek des Tycho Brahe (Vienna: Herbert Reichner, 1933), p. 12.

[7]Wilhelm Norlind, Tycho Brahe: En Levnad Stockning (Lund: Gleerup, 1970), p. 352. [Hereinafter cited as Norlind, Tycho Brahe].

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from Henry Brucaeus[1] in 1584, having requested it earlier.[2] He also had copies of the Ephemerides Novae, the Observatio & Demonstratio, the Consideratio & Observatio, and Frischlin's 1573 tract containing Maestlin's work. Tycho may also have had a copy of the Epitome Astronomiae.[3]

While Tycho could not agree with Maestlin on many particulars (cometary theory, Copernicanism, calendar reform, and a priori astronomy), he nevertheless criticized him only mildly and praised him highly. Considering the paucity of praise from Tycho for anyone, that for Maestlin was great indeed.

A friend and correspondent of Tycho's, Christopher Rothmann (c. 1550- c. 1605), was also aware of Maestlin's work. Rothmann, of whom little is known, was astronomer to the Landgrave Wilhelm IV of Hesse-Kassel from 1584 to 1590. A Copernican like Maestlin, he had probably heard of him through Tycho's works. One letter, dated 2 March 1587, from Rothmann to Maestlin survives. In it he discusses his observations of the comet of 1585, requests a copy of Maestlin's treatise on the comet of 1580, and mentions the Gregorian calendar.[4]

Another contemporary who took an interest in Maestlin's work was Tycho's friend, the Bohemian doctor Thaddeus Hagecius ab Hayck (Tadeáš Hájek z Hájku). Educated in Prague and Vienna, Hagecius was not only

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[1]Letter of 12.6.1584 (o.s.), Tycho, Op. Om. VII, p. 86. Brucaeus refers to the work as De emendatione calendarii. Whether the copy is that of 1583 or 1584 is not known.

[2]Tycho, Op. Om. VII, p. 82.

[3]Mentioned by neither Prandtl nor Norlind, this may be the work which Tycho mentions as "libellum etiam sphaericum" of Maestlin's which Brucaeus had sent in 1584. Tycho, Op. Om. VII, p. 82.

[4]Cod. Guelf. 15.3 Aug. 2°, fol. 84.

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court physician to Emperors Maximilian II and Rudolf II, but also a mathematician, astronomer, astrologer, and bibliophile.[1] He was much addicted to pseudo-scientific pursuits such as chiromancy, metoposcopy, and iatromathematics. He wrote his Dialexis on the new star of 1572 and published two works on the comet of 1577. Hagecius saw Maestlin's tracts on both the 1572 nova and the comet of 1577, thinking them both scholarly; however, in his Descriptio Cometae, qui apparuit Anno Domini MDLXXVII (Prague, 1578), he concluded that the comet was in the elementary regions of the world.[2]

In 1580, Hagecius wrote a second work on the comet of 1577,[3] this time attacking Maestlin and Röslin. Although Hagecius admired the ingenuity of Maestlin, he felt the latter had used insufficient data and thus could not draw the conclusions he did. Furthermore, Maestlin could not hope to ascertain the orbit of the comet from a few months' observations much less hypothesize on the orbits of all comets. Hagecius' scepticism of Maestlin's demonstrations was correct enough, but it lost some of its force due to his own conclusions about the comet. Hagecius carried on his attack against Maestlin in his correspondence with Tycho. Tycho had praised Maestlin to Hagecius in a letter of 25 January 1587 although

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[1]Hagecius penned several medical works: among his astronomical and mathematical works are his Oratio de laudibus geometriae (Prague, 1557); Diagrammata seu Typi Eclipsium Solis et Lunae futuarum (Prague, 1551); Astrologica opuscula antiqua (Prague, 1564); Czech-language works on the comets of 1556 and 1580; and tables for the correction of clocks.

[2]Hagecius found a large parallax for the comet. See Hellman, Comet of 1577, pp. 200ff.

[3]Thaddaei Hagecii ab Hayck Epistola Ad Martinum Mylium. In qua examinatur sententia Michaelis Moestlini et Helisaei Roeslin de Cometa Anni 1577. The contents are briefly described in Hellman, Op. Cit., pp. 203ff.

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he was somewhat suspicious of the use of the thread for observation.[1] Hagecius replied on 1 November 1588, saying that although Maestlin's book was beautiful and subtle, beauty and subtlety did not replace the truth; he then repeated his view of the incorrectness of Maestlin's parameters.[2] Exactly one year later Tycho gave a lengthy rebuttal to Hagecius,[3] yet the latter persisted in his criticism of Maestlin in his letter of 11 June 1590.[4] Maestlin did not reply to the printed attack of Hagecius and was probably unaware of Tycho's defense of him, for Tycho's 1598 letter to Maestlin does not refer to the Bohemian physician.

Even less well-disposed toward Maestlin was David Fabricius (1564-1617), Frisian astronomer and ardent correspondent of Kepler who, writing to the latter on 20 January 1607 (n.s.), said:

> Maestlin, too, has published a book on the irregularity of motions but I have not seen it. I wonder at that man who for many years has laboured in astronomy yet has produced nothing of use for the true correction of the motions.[5]

Tycho's one-time assistant Gellius Sascerides, on the other hand, praised Maestlin in a letter to the Tübingen astronomer. Tycho had sent copies of his newly-published De Mundi aetherei recentioribus phaenomenis (1588) to Rothmann and Maestlin, employing Gellius as his messenger. In his effusive letter of 23 July 1588 to Maestlin, Gellius passed along Tycho's request:

> And so, trusting as much as I am able in your humanity, your liberal benevolence towards everyone, and your truly great

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[1] Tycho, Op. Om. VII, p.112.

[2] Ibid., pp. 146-47.

[3] Ibid., pp. 205ff.

[4] Ibid., p. 247.

[5] GW XV, No. 408, p. 380:164-66.

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> mathematical and astronomical studies, I ask of you, most distinguished sir, that you detach yourself from your great work and carefully read Tycho's book through so that Tycho might understand from your letter your opinion of his work.[1]

Gellius' praise for Maestlin may have been sincere but suggests what Tycho felt for Maestlin. Of course, his praise may have simply been a device to elicit a response from Maestlin.

Although neither a friend nor a correspondent, we cannot exclude Galileo Galilei from this discussion. There seems to be a general feeling that Maestlin never spoke well of Galileo.[2] Indeed, there is little mention of Galileo in any of the correspondence between Kepler and Maestlin. The first Maestlin heard of Galileo was probably in a letter from Kepler of October 1597 in which Kepler mentions that a copy of his Mysterium Cosmographicum had reached the Italian:

> Recently I sent to Italy two copies of my work (or rather your work) which were received most gratefully and with sincerest pleasure by the Paduan Mathematician, named Galileus Galileus, as he signs himself.[3]

Kepler goes on to say that this Galileo was a Copernican. This remark elicited no response from Maestlin, nor did the appearance of Maestlin's name in the book's passages cause any remark by Galileo. No doubt, this showed that neither Maestlin nor Kepler had heard of Galileo previously.

This exchange of letters has sparked a small controversy,[4] but

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[1] Cod. Math. 2° 14. If Maestlin did write an opinion of Tycho's work, it is unlikely to be extant. Tycho does not mention having heard Maestlin's views on the book.

[2] Mentioned in S. Drake, Galileo Studies (Ann Arbor: University of Michigan Press, 1970), p. 138n.

[3] GW XIII, No. 75, p. 143. Also in NE X, No. 69.

[4] See Ludovico Geymonat, Galileo Galilei (New York: McGraw-Hill, 1965), p. 230n. E. Rosen's answer "Galileo and Kepler: their first two contacts," Isis 57 (1966), pp. 262-64. See also: Giorgio Tabarroni, "Recensioni," Physis IX, fasc. 2 (1967), pp. 248-54, and Drake, Galileo Studies, ch. 6.

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suffice it to say that Maestlin would have had no reason to know about Galileo, who had neither publicly come out as a Copernican nor, in fact, ever published anything on astronomy. Galileo's book on the proportional compass was not written until ten years later (being his first major publication), so Maestlin could not have read any Galileo -- assuming that Maestlin could easily read Italian, which he could not.

Although the name Galileo meant nothing to Maestlin in 1597, it was certainly well known to him by 1610 after the publication of the Sidereus Nuncius. I have seen no evidence that Maestlin ever read the work, but he did receive a copy of Kepler's commentary, the Dissertatio, and a copy of Martin Horky's Brevissima peregrinatio contra Nuncium Sidereum of 1610. Maestlin's reaction to Kepler's book has been misunderstood, I think, by taking his comments out of context. It is curious that most of the contemporary readers of Kepler's essay saw it as a subtle refutation of Galileo. Galileo, himself, did not see it so, but considered it a flattering, valuable work. On Maestlin's (and others') opinions, Koestler has commented:

> Living in an atmosphere saturated with malice, Professors Magini, Horky, and even Maestlin could not believe their ears when they heard Kepler singing Galileo's praises, and they tried to discover some hidden sting in the treatise. They gloated over a passage in which Kepler showed that the principle of the telescope had been outlined twenty years before by one of Galileo's countrymen, Giovanni Della Porta, and by Kepler himself in his work on the Optics in 1604.[1]

As far as Magini and his student Horky were concerned, the statement was correct. Maestlin, however, was not so malicious. In a letter to Kepler he says:

> You most certainly have pulled the feathers from Galileo in your book (a copy of which was sent by you to me and was read

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[1]Koestler, Sleepwalkers, p. 378.

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> with great delight, for which I also send you much thanks), namely because he was not, himself, the first inventor of the new telescope; because he is not the first in the world to show there are more stars in the heavens, how, that up to now, we have the remarks in the writings of the ancients, and there are other such writings.[1]

Maestlin was undoubtedly glad to see that Kepler had given him the credit for the discovery of the nature of lunar spots, the atmosphere of the moon, and the true nature of the ashen colour of the unlit portion of the moon. By congratulating Kepler for "depluming" Galileo, Maestlin was not necessarily suggesting that Galileo had written nonsense (as Horky maintained) or even that his rediscovery of some of Maestlin's ideas was insignificant.

Before assuming the malice on Maestlin's part, one should read further:

> One thing remains that he can still exult in: namely, his observation of the four new planets around Jupiter. None of the outsiders is able to wrest that club of his from his hands, because in this affair none of the arguments of theology, philosophy, astronomy, optics, etc. is effective. It can elude all of them. Now, the Holy Scriptures has not disclosed the number of planets; in fact, it asserts rather the immense wisdom and power of God, which our minds cannot grasp. Philosophy is not perfectly known to us; but wherever we turn [in philosophy] we see just a few things of the infinite that are known to us and daily more is discovered that was unknown before.[2]

Maestlin then goes on to recount the new discoveries in algebra that mathematicians had not hitherto suspected.

Galileo's knowledge of Maestlin came chiefly by way of Tycho and Kepler. Galileo, in his Difesa . . . Contro alle Calunnie & Imposture di Baldessar Capra of 1607, took Capra to task for having ignored the use of the thread in parallax determinations. Had Capra carefully read

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[1] GW XVI, No. 592, p. 333:11-17.

[2] Ibid., p. 334:19-28.

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Tycho's work, Galileo points out that he would have learned of that method " . . . much celebrated in the work of Michael Maestlin written on the new star of 1572, of which he observed its place, immobility, and lack of parallax by no other means than with a thread, always finding [the nova] on a straight line with two pairs of fixed stars . . ."[1] He also noted that Maestlin had seen the new star of 1572 in the first week of November.[2] Both references to Maestlin's observations were drawn from Tycho's Progymnasmata.

Galileo defended Maestlin (among others) against Chiaramonti. In the Dialogue, Salviati says:

> . . . the others [refutations of Copernicus] have been inserted by a great philosopher and mathematician in a treatise of his in favor of Aristotle and his opinion about the inalterability of the heavens. In this is proved that not only the comets but the new stars (that is, the one of 1572 in Cassiopeia and that of 1604 in Sagittarius) were not above the spheres of the planets at all, but were actually beneath the moon's orbit in the elementary sphere. And he proves this against Tycho, Kepler, and many other astronomical observers, beating them with their own weapons; that is, by means of parallaxes.[3]

Galileo was also aware of certain of Maestlin's ideas expressed in Kepler's Dissertatio cum Nuncio Sidereo. Both Tycho's and Kepler's works were the source of knowledge, although scant, of Maestlin for many Italians.[4]

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[1] NE II, p. 527.

[2] Ibid., p. 284. (Among fragments collected by Favaro under the rubric "Frammenti di Lezioni e di studi sulla Nuova Stella dell'Ottobre 1604.")

[3] Galileo, Dialogue, p. 218. He alludes to Chiaramonti's De tribus novis stellis. See below, p.195.

[4] For example, Francesco Sizzi's Dianoia of 1611 against Galileo's Sidereus Nuncius mentions that Maestlin and Kepler held that Venus was "below the sun." (NE III, p. 235.) The Italian Jew Isaac Cardosa dedicated a Free Philosophy to the Doge of Venice in 1673 which gave a list of prominent Copernicans, including Maestlin. See Thorndike, History of Magic, VII, pp. 682-83.

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Two Italians who took some notice of Maestlin were Scipio Chiaramonti and G.B. Riccioli. Giovanni Baptista Riccioli (1598-1671), a Jesuit and well-known writer on astronomy, was best known for his monumental defence of geocentric astronomy, the Almagestum Novum of 1651. Maestlin, along with a great number of other astronomers, is mentioned several times in the work. In Riccioli's biographical synopsis of astronomers, Maestlin is referred to in a paragraph which enumerates a few of his publications and mentions his adherence to Copernicanism, which Riccioli saw as "Maestlin's heresy." In addition, Maestlin's attack on the Gregorian Calendar did not go unnoticed for Riccioli knew that Maestlin was the adversary of "our Clavius." But, Riccioli added, Clavius had silenced Maestlin's opposition.[1]

Riccioli mentioned several of Maestlin's observations, including those of the eclipse of 1590 (taken from Kepler's Optics), the "rainstorm" on the moon (also taken from Kepler), and his observations of the new star of 1572 and the comet of 1577. The latter observations were taken from Tycho's works on the subjects, and in both cases Riccioli attacked Maestlin's conclusions.[2] As a Jesuit and anti-Copernican, Riccioli had little positive to say about Maestlin. Still, he had enough stature in Riccioli's eyes for him to include his name on the lunar map he had constructed; the crater "Maestlin" was assigned in the Oceanus Procellarum.[3]

Scipio Chiaramonti or Claramontius (1565-1652) included Maestlin among the supporters of Tycho in his Anti-Tycho of 1621. Chiaramonti

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[1] G.B. Riccioli, Almagestum Novum (Bononiae: Haeredis Victorii Benatii, 1651), I, xli. Clavius had not, of course, silenced Maestlin on the subject.

[2] Ibid., II, p. 87 and pp. 152-53.

[3] Steiff, "Michael Mästlin," p. 49.

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would not allow comets and new stars to be supra-lunar objects, and Maestlin had agreed with Tycho on the supra-lunar position of the new star of 1572 and the comet of 1577. Maestlin's observations were taken from Tycho's Progymnasmata and De Mundi aetherei recentioribus phaenomenis, not from Maestlin's works themselves. Some years after the appearance of the new star of 1604 and comets of 1618, Chiaramonti published his De Tribus Novis Stellis . . . Adversus Tychonem, Gemmam, Maestlinum . . . which, despite the title, does not mention Maestlin except to remark on the latter's observations of the new star of 1604. He took these observations of Maestlin from Kepler (since Maestlin had published no work on the subject). He does not identify Maestlin as a Copernican even though he was probably aware from Kepler's works that Maestlin was one; however, Chiaramonti was an adherent of the traditional astronomy and thus would have been opposed to Maestlin for that reason as well.

In France, Marin Mersenne (1588-1648), who possessed an encyclopedic knowledge of contemporary science, also took notice of Maestlin. In his early Quaestiones celeberrimae in Genesim he defends the notion of the stability of the earth and names Maestlin as one who would have the earth move.[1] Later in the same work, Mersenne places Maestlin's name among those who were against the accepted tradition of astronomy: Copernicus, Kepler, Bernard, Patrizzi, and Origanus -- a curious collection.[2] In his Les Questions Theologiques of 1634, Mersenne quotes

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[1]Marin Mersenne, Quaestiones celeberrimae in Genesim (Paris, 1626), cap. v, versicule x, col. 890. "Maestlinus ait nubes aeque cito atque terram moveri." [Hereinafter cited as Mersenne, Quaestiones.]

[2]Ibid., col. 895. Mersenne does not identify "Bernard" further; the two most likely candidates would have been Bernard of Verdun (13th century), whose Tractatus super totam Astrologiam rejected Aristotle's homocentric astronomy; and Bernardino Telesio (1509-88), who attacked Peripatetic philosophy in his De rerum natura juxta propria principia (Rome, 1565).

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Maestlin's report on the lunar eclipse of 1590;[1] just as Riccioli had done, Mersenne doubtless went to Kepler's Optics for his information. His knowledge of Maestlin's views on the motion of the earth likewise came from Kepler's Mysterium Cosmographicum (preface to Rheticus).

Maestlin's Epitome Astronomiae reached England and was employed by Thomas Blundeville (fl. c. 1600). Blundeville's Theoriques of the Seven Planets of 1602 was the first English-language textbook of mathematical astronomy and there he says that his work was:

> . . . collected, partly out of Ptolemy, and partly out of Purbachius, and of his Commentator Reinholdus, also out of Copernicus, but most out of Mestelyn, whom I have cheefely followed, because his method and order of writing greatly contenteth my humor.[2]

Blundeville relied upon Maestlin's work, I assume, essentially because of its innovative didactic style and because it was the first major textbook on the sphere which also treated planetary theory.[3]

Maestlin's observations of the new star of 1572 were mentioned and praised by a countryman of Blundeville's, William Gilbert. Gilbert (1540-1603) is best known for his De Magnete, but wrote another work of astronomical relevance, his De Mundo nostro sublunari Philosophia Nova which was completed before his death but not published until 1651. Gilbert mentions Maestlin twice[4] along with Tycho, Munosius, Cornelius Gemma,

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[1] Marin Mersenne, Les Questions Theologiques (Paris, 1634), p. 54. Mersenne refers to him as "Moestlin excellent astronome de Tubinge."

[2] Cited in F.R. Johnson, Astronomical Thought in Renaissance England (Baltimore: Johns Hopkins Press, 1937), p. 212.

[3] I have not seen this work. Johnson says of it (Ibid.) that "Fundamentally, the work is the Theoricae novae planetarum of Peurbach, brought up to date by comparison with the books by the ablest subsequent writers and commentators."

[4] William Gilbert, De Mundo nostro sublunari Philosophia Nova (Amsterdam: Elzevir, 1651), p. 155 and p. 236.

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Hagecius, Digges, and Dee for their observations of the new star. It is quite unlikely that Gilbert saw Maestlin's tract in Frischlin's book but, like most continental writers who mentioned Maestlin, relied upon Tycho's Progymnasmata.[1]

Finally, those persons who helped save Maestlin's observations should be mentioned. These observational records had been purchased by Emperor Ferdinand III (1608-1658) from the papers of Schickard[2] and were placed in the Imperial Library in Vienna, where they remain today. Albert Curtius, a Jesuit, collected a number of Maestlin's observations and published them in his Historia Coelestis of 1672 along with those of the ancients, Tycho, and others.[3]

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[1] See my note forthcoming in Isis.

[2] Steiff, "Michael Mästlin," p. 49.

[3] Kästner, Geschichte, II, p. 642.

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CONCLUSIONS

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CONCLUSIONS

Known essentially as an astronomer, Maestlin maintained a diverse number of interests. He knew a great deal of calendrical history and theory which he put to use in the debate over the Gregorian calendar reform. He was one of the most formidable opponents of the reform, eliciting a rebuttal from Clavius himself. His chronological work was careful and comprehensive; he carried his critical acumen to his historical work and relied upon astronomical reasoning when the opportunity presented itself.

He was, above all, an outstanding teacher. He kept abreast of mathematical developments and taught more than the Euclid that was expected of him. Algebra, logarithms, the latest advances in geometry and trigonometry were all subjects for his study. His textbook on astronomy was the most complete and intelligently written available, reflecting his desire to instruct well. Many of his students, such as Kepler, Schickard, Hafenreffer, Andreae, and Galgemair were inspired by him. To Maestlin we must attribute much of Kepler's early interests and training. While it has always been assumed that Kepler was led to Copernicanism by him, there seems to be more that was taken from him by Kepler. Kepler's passion for mathematics, studies in chronology, restraint in astrology, and great interest in lunar astronomy were, to an extent, reflections of Maestlin's thought and work. A further examination of his other students might expose more of Maestlin's influence than this study has

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suggested.

As an observational astronomer, Maestlin was careful and resourceful. He desired to improve the quality of observations and, with it, the whole of astronomy. He made a large number of careful eclipse observations because he knew the weaknesses of the astronomical tables could be removed only by precise observation. The sun and moon were fascinating objects for him: he wished to know more about their surface features and made conjectures concerning them, many of which were later shown by Galileo's telescopic observations to be accurate. Not content to accept the traditional views concerning their natures, he advanced remarkable ideas about them such as the atmosphere of the moon, the location of the sunspots on the solar surface, the mountains and valleys on the moon, and the possibility of lunar inhabitation.

When confronted with the nova of 1572, he did not hesitate to break with the Peripatetic philosophy nor to state that change could occur in the heavens. Having found no parallax for the comet of 1577, he saw that comets did not always conform to Aristotle's opinions; not only was that comet supra-lunar, it was also ordered by celestial laws--a seminal idea. Maestlin was the first astronomer to give an orbit for a comet, an idea which was rapidly adopted in the next half-century. By deciding upon the true planetary theory with his orbit of the comet, Maestlin was suggesting that there was a connection between cometary and planetary theory, an idea never before developed. After Newton's work, of course, the connection was obvious. It was, in fact, this decision of Maestlin's that helped Kepler to accept the heliocentric theory. Although Maestlin retained much of the traditional theory of comets' physical nature, his conclusions concerning their motions were a great

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stride forward.

His works on the comet of 1580 and the great comet of 1618 were not as comprehensive, but he maintained his views on comets. By 1618, he saw that every nova and comet he had seen since 1572 had been supra-lunar and bound by astronomical laws.

Maestlin was not prepared to forsake traditional kinematic astronomy for physical causation as Kepler applied it. He desired solid, geometrical demonstration for astronomical theory, firmly grounded on precise observation. Astrology did not conform to this criterion and he thus rejected it. Maestlin was not a secret Copernican. Already interested in the heliocentric theory in his school days, he unhesitatingly announced his partisanship in 1578 after his comet observations. He stated his preference again in his Ephemerides Novae, and steered Kepler's first Copernican book through the press in 1596. He spoke favourably of Kepler's a priori reasoning both in his preface to the new edition of Rheticus' Narratio Prima and to the Tübingen authorities as well as the duke of Württemberg. He desired a new edition of Copernicus' De Revolutionibus with Rheticus' work. While he was forestalled by a reluctant printer, he was not fearful of undertaking such a project. Copernicus was mentioned in his Tübingen lectures and pedagogical works, not slightingly, but with admiration. He held his opinions openly and suffered no persecution from his colleagues, even from Hafenreffer who was highly critical of Copernicus.

Maestlin was helpful to his friends, kind and thoughtful. His scientific thought reflects caution and prudence, yet he could differ significantly from accepted opinion when he thought the traditional reasons were ill-founded. His whole work shows competence and confidence.

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That Maestlin should have such a rich gamut of interests, wide influence, and many progressive ideas suggests that the contributions of the many second-rank scientists, who have hitherto been largely ignored, may be very extensive.

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APPENDICES

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APPENDIX A

MAESTLIN CHRONOLOGY

1550	born in Göppingen, 30 September
1568	matriculates at University of Tübingen
1569	B.A. at Tübingen
1571	M.A. at Tübingen; tutor in theological faculty
1572	observes Tycho's Star; tutor in mathematics at Tübingen
1576	appointed Deacon at Backnang
1577	observes comet of 1577; marries first wife
1578	published Observatio & Demonstratio
1580	named Professor of Mathematics at Heidelberg; observes comet of 1580; publishes Ephemerides Novae
1581	publishes Consideratio & Observatio
1582	publishes Epitome Astronomiae
1583	opens attack on Gregorian Calendar; publishes Außführlicher Bericht
1584	named Professor of Mathematics at Tübingen
1586	publishes Alterum Examen
1588	death of first wife; publishes Defensio Alterius
1589	marries for second time
1596	aids in publication of Kepler's Mysterium Cosmographicum
1593-1624	publishes various disputations, treatises, and editions of Epitome
1604	observes new star of 1604
1618	observes great comet of 1618

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1622 death of second wife

1631 dies in Tübingen, 20/30 October

1641 Hafenreffer publishes Maestlin's Chronologicae Theses

1642 Andreae publishes Maestlin's Synopsis Chronologiae Sacrae

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APPENDIX B

The Printed Works of Michael Maestlin

In this section I will list in chronological order of publication the printed works of Maestlin that are known. The location of copies will be included if I know the work to be extant. Together with the publishing information I have included the numbers from Houzeau-Lancaster[1] (abbreviated H-L), and Zinner[2] and whether the work is included in the bibliography given by Hellman.[3]

1. Erasmus Reinhold. Prutenicae Tabulae Coelestium motuum. Tübingen, 1571. This was the second edition of Reinhold's work with an afterword by Maestlin (according to Zinner No. 2553 and H-L No. 12727). Not listed by Hellman. As I have not seen this work, I cannot attest to Maestlin's editorship.

2. Demonstratio astronomica loci stellae novae, tum respectu centri mundi, tum respectu signiferi et aequinoctialis. (dated 1573)

This work was published first by Nicodemus Frischlin in his Consideratio novae stellae (Tübingen, 1573), 4°. Maestlin's tract ran from page 27 to 32.[4] There is a copy in the UT. The tract was reprinted by Tycho in his Progymnasmata, pp. 544-548. Zinner No. 2622. Noted in Hellman.[5]

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[1] J.C. Houzeau and A. Lancaster, Bibliographie Générale de l'astronomie (Brussels: Hayez, 1887-9).

[2] Zinner, Bibliographie.

[3] Hellman, Comet of 1577, pp. 142-144.

[4] According to Norlind, Tycho Brahe, p. 352.

[5] Comet of 1577, second edition, 1971.

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3. Beobachtungen des neuen Sterns in Cassiopea. Listed by Poggendorf,[1] Hoefer,[2] and Hellman, this work seems to be a bibliographic ghost.[3]

4. Ephemeris Nova Anni 1577. Sequens ultimam hactenus a Ioanne Stadio Leinouthesio editarum Ephemeridum, supputata ex tabulis Prutenicis. Tübingen, 1576.

Given by H-L, No. 14838 but given no number by Zinner; not mentioned by Hellman. This work seems to be a shorter version of Item 6 (computed for only one year). Copy in the Bibliothèque Royale Belgique.[4]

5. Observatio & Demonstratio Cometae Aetherei, Qui Anno 1577. Et 1578. Constitutus in Sphaera Veneris, Apparuit, Cum Admirandis eius passionibus, varietate scilicet motus, loco, orbe, distantis à terrae centro, &c. adhibitis demonstrationibus Geometricis & calculo Arithmetico, eiusmodi de alio quoquam Cometa nunquam visa est. Tübingen: Georg Gruppenbach, 1578. 4°.

Listed by Hellman and Zinner No. 2836. Copies in BM, BN.

6. Ephemerides Novae, ab anno salutiferae incarnationis 1577, ad annum 1590. Supputatae ex tabulis Prutenicis. Tübingen: Georg Gruppenbach, 1580. 4°.

Given by Zinner as No. 2940, H-L No. 14838, and noted by Hellman, this work is now in the BM, BN, Columbia University and Burndy Libraries.

7. Consideratio et Observatio Cometae Aetherei Astronomica, Qui Anno MDLXXX Mensibus Octobri, Novembri, et Decembri, in alto Aethere apparuit. Item, Descriptio terribilium aliquot & portensorum Chasmatum, quaebis annis MDLXXX & MDLXXXI conspecta sunt. Heidelberg: J. Mylius, 1581.

Given by Hellman. Copies are in the BM, BN, University College (London), ÖNB, and Royal Astronomical Society.

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[1] J.C. Poggendorf, Biographisch-Literarische Handwörterbuch zur Geschichte der Exactenwissenschaft (Leipzig: Barth, 1863-), II, p. 170. [Hereinafter cited as Poggendorf, Handwörterbuch].

[2] Hoefer, Biographie, XXXII, p. 649.

[3] See above, section 3.2.

[4] According to C. D. Hellman, Private Communication of 7.7.1970.

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8. Divino Rectoris Astrorum Favente Numine De Astronomiae Principalibus et Primis Fundamentis Disoutatio ad discutiend... proposita M. Michaele Maestlino Goeppingensi, Matheseos in antiquißima & inclyta Academia Heidelbergensi professore, in auditorio philosophico, ad diem 20. Ianuarii. Respondente Hieremia Iacobo Ulmensi. Heidelberg: Jacobus Mylius, 1582.

Given by Hellman only. Another work is given in the same place as De Astronomiae principalibus et primis fundamentis, but it is the same work with an abbreviated title. Copy in NYPL.

9. Epitome Astronomiae, Qua Brevi Explicatione Omnia, Tam ad Sphaericum quam theoricam eius partem pertinentia, ex ipsius scientiae fontibus deducta, perspicue per quaestiones traduntur, conscripta per M. Michaelem Maestlinum Goeppingensem, Matheseos in Academia Tubingensi Professorem. Tübingen: Georg Gruppenbach, 1583, 1593, 1597, 1598, 1610, 1624.

A first edition was published in 1582 at Heidelberg, presumably by Mylius. The editions of 1582 to 1593 were quarto, the remaining octavo. Although I know of no copies of the 1582 edition, it must have existed as later editions had the phrase "Iam nunc ad ipso Autore diligenter recognita" added to the title. Hellman lists all editions; H-L No. 2747, Zinner Nos. 3041, 3299, 3539, 3779, and 4984. Copies exist in the BM (1597, 1610) and the BN (1588, 1598, 1624). Editions of 1610 and 1624 had some new material added.[1]

10. De astronomia hypothesibus sive de circulis sphaericus. Heidelberg, 1582.

Only Zinner (No. 3040a) gives the title. Maestlin was supposed to have presided while one Master Menu responded. I known nothing of this work; its title suggests the content of Item 8.

11. A commentary by Maestlin of Regiomontanus' Ephemeriden. Tübingen, 1582 and 1610.

This title is given only by Hellman. The commentary was part of the Ephemerides Novae (1580), the 1582 and 1610 dates being incorrect.

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[1]See above, 3.3.

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12. Außführlicher und Gründtlicher Bericht von der allgemainen und nunmehr bey sechßehen hundert Jaren von dem ersten Keyser Julio biß auff leßige unsere Zeit im ganzen h. Römischen Reich gebrauchter Jarrechnung oder kalender in was Gestalt er anfänglich gweßt und was durch länge der Zeit für Irthumb dareyn Seyen eyngeschlichen. Item ob und wie er widerumb ohn meckliche verwährung zu verbesseren were. Sambt erklärung der newen Reformation welche jetziger Bapst in Rom Gregorius XIII. in demselben kalender hat angestellet und an vilen Orten eyngeführet und was darvon zuhalten seye. Heidelberg: Jacob Müller, 1583.

This title in given only in Hellman, and a copy exists in the NYPL. Hellman gives another title, Dialexis Germanica, with the date 1583, and Maestlin himself refers to this title. The Dialexis is the same as the Außführlicher und Gründtlicher Bericht. Zinner (No. 3144) and H-L (No. 13038) give an additional title, Gründlicher Bericht von der allgemeinen von dem 1. Kayser Julio bis auff unsere Zeit . . ., also from Heidelberg, 1583. This is the same work as Item 12. Maestlin's treatise was reprinted the following year in J. Spies' Heidelberger Sammelband together with other works on calendar reform. Spies' title for the collection was Notwendige und gründtliche Bedennckhen von dem allgemeinen Uralten und nu mehr bey sechsehen hundert Jaren gebrauchten Römischen Kalender wie und ob etlich Irrthumb hiezwischen in demselbigen eyngeschlichen seyen. Item ob und wie sie zu corrigieren oder zu verbessern weren. The title is an obvious imitation of Maestlin's, but the volume includes other treatises. This latter work is given by Hellman, H-L No. 13795 (with an incorrect title), and Zinner No. 3144 (with an incorrect title). Copies in the BM, BN, and University College (London).

13. Alterum Examen Novi Pontificalis Gregoriani Kalendarii, quo ex ipsis fontibus demonstratur, quod novum Kalendarium omnibus suis partibus, Quibus Nam rectissime reformatum vel est, vel esse putatur, multis modis mendosum, & in ipsis fundamentis vitiosum sit. Tübingen: Georg Gruppenbach, 1586. 4o.

Given by Hellman and H-L No. 13807. A copy is in the BM.

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14. Judicium M. Moestlini de opere astronomico D. Frischlini.

Dated 18.1.1586 but not printed. Listed only by Hellman. It is not certain that the work is extant. Described in Strauß, Nicodemus Frischlin, pp. 328ff.

15. Defensio Alterius Sui Examinis, Quo Ex Ipsis Fundamentis Demonstraverat, Quod Gregorianum Novum Kalendarium omnibus suis partibus, quibus quam rectissime reformatum vel esse debebat, vel esse putatur totum sit vitiosum. Adversus Eiusdem Antonii Possevini Jesuitae ineptissimas elusiones, quibus ipse dum Examen illud extenuat & calumniis carpit, non solum imperitiam & vanitatem suam prodit, verum etiam (licet invitus & non comitans) Novam Gregorianam Kalendarii emendationem magis confundit, & funditus everit. Tübingen: Georg Gruppenbach, 1588. 4°.

Given by Hellman and H-L No. 13811. A copy is in the BM.

16. Disputationes tres astronomicae et geographicae. Tübingen, 1592. 4°.

Given by Hellman, H-L No. 2748, and Zinner No. 3505. According to H-L reference, this work was translated by "Begern (?)" as Problema astronomicum die Situs, der Sternen, Planetarum oder Cometarum zu observirn in 1619. A copy of this work, by Matthäus Berger, is in the Crawford Library, Edinburgh. The Latin original was in Stuttgart but was lost by fire during the last war.[1]

17. Apologia examinum suorum. . . Tübingen, 1593. 4°.

Given by H-L No. 13815 and Zinner No. 3540. The work does not seem to be extant.

18. Disputatio de eclipsibus Solis et Lunae. Tübingen, 1596.

Given by Hellman, H-L No. 2749, and Zinner No. 3669. Hellman gives an additional title Theses de Eclipsibus published in Tübingen in 1606. This is the same work.[2] The disputation was defended by Marcus Hohenfeld, and is referred to by Kepler in his Astronomiae pars Optica. The work was originally in Stuttgart but was lost like Item 16.

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[1] Martha List, Private Communication 7.12.1970.

[2] Ibid.

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19. De Dimensionibus Orbium Et Sohaerarum Coelestium Iuxta Tabulas Prutenicas, ex sententia Nicolai Copernici. Tübingen: Georg Gruppenbach, 1596.

Printed as an appendix to Kepler's Mysterium Cosmographicum, pp. 161-81.

20. Georg Joachim Rheticus. Narratio Prima. Tübingen: Georg Gruppenbach, 1596.

Printed with Item 19 with a new introduction and revisions by Maestlin.

Printed again in the 1621 Frankfurt edition of Kepler's work.

21. Examina eorumdemque apologia. . . Tübingen, 1597, 4°.

Given by Hellman, H-L No. 13823, and Zinner No. 3724. This work does not seem to be extant.

22. Disputatio de multivariis motuum planetarum in coelo apparentibus irregularitibus, seu regularibus inaequalitatibus, earumque causis astronomicis. Tübingen, 1606. 4°.

Given by Hellman, H-L No. 2750, and Zinner No. 4104. Zinner (No. 4103a) adds another title--Disputatio de Inaequalitatibus motuum coelestium--for Tübingen, 1606, but it seems to be the same work. A copy existed in Stuttgart but was lost with Items 16 and 18.

23. De Cometa anno 1618. Tübingen, 1619.

Given by Hellman and Zinner No. 4750. This work is probably a bibliographic ghost.[1] Part of the work is in MS in the WLB (Cod. Math. 4°15^{b}, 8).

24. Chronologicae Theses et Tabulae Breves contractaeque, ad investiganda tempora historiarum et epocharum potissimarum, praesertim sacrarum ... cum exegesi quaestionum chronologicarum. Tübingen: P. Brunius, 1641 and 1646.

This work by Maestlin was published posthumously by S. Hafenreffer.

Listed only by Hellman, a copy is in the BN.

25. Synopsis Chronologiae Sacrae. Lunebourg, 1642.

This work by Maestlin was published posthumously by Johann Valentin

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[1]See above, 3.2.

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Andreae. Listed only by Hellman, I know of no copy, although a MS in HAB seems to be part of the book.

26. Perpetuae delucidationes Tabularum Prutenicarum coelestium motuum. Tübingen, 1652. 4°.

Listed by Hellman, Poggendorf,[1] and H-L No. 12769; not listed by Zinner. I have seen no information concerning this work and cannot definitely ascribe it to Maestlin.

Additional Titles:

27. Horologium solarium informatio. 1590.

Doppelmayr places this among Praetorius' MSS but may have confused it with Maestlin's 1613 lectures (now in Erlangen), or with the MS "Tabula Motus Horarii" of ca. 1586 (in NYPL). Zinner lists the work as No. 3386.

28. Tractatus brevis de dimensione Triangulorum rectilineorum & sphaericorum. n.d.

Another MS which Doppelmayr places among those of Praetorius. Poggendorf also notes it.[2] If such a work were written, it does not seem to have been published in Maestlin's lifetime; there is a MS in Stuttgart which might be the same.[3]

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[1] Poggendorf, Handwörterbuch, II, p. 170.

[2] Ibid.

[3] Cod. Math. 4° 15b Nr. 4; see above, section 2.4.

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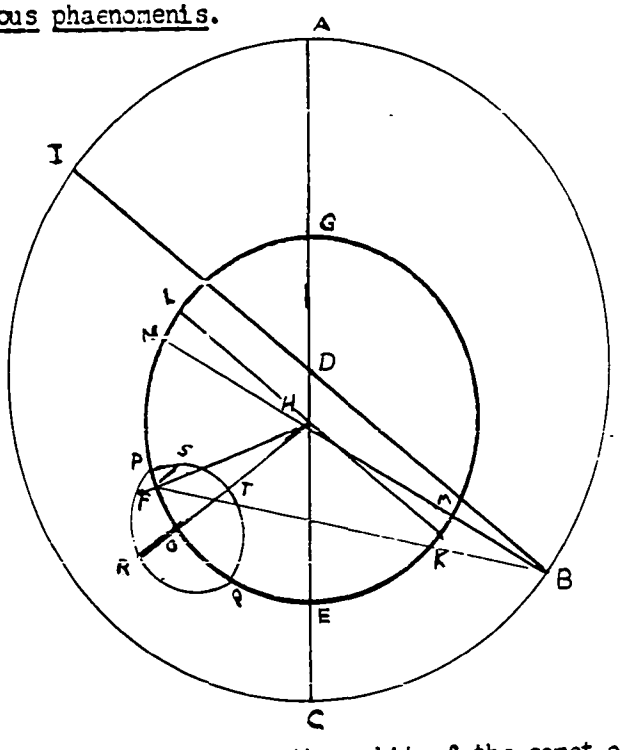
APPENDIX C

TECHNICAL APPENDIX TO CHAPTER III

This analysis is adapted from Chapter 8 of the Observatio & Demonstratio; it is also found in Chapter 10 of Tycho's De Mundi Aetherei recentioribus phaenomenis.



The diagram represents the orbit of the comet of 1577 and its relation to the earth's orbit. The circle ABCI represents the earth's orbit about the sun, D. Circle ELG represents the comet's deferent about its centre H which is also the centre of equal motion of Venus. The eccentricity of the comet's orbit, DH, is 0.0246 (where the mean distance of the earth from the sun is 1.000) and is the same as Venus' eccentricity. Line GHE is the line of apsides of both the comet and Venus, G being the apogee and E the perigee (aphelion and perihelion were not yet in common

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use). The earth moves counterclockwise (CBAI) while the comet moves in the opposite direction (ELG). In the diagram, the earth is at B, the comet at F. A line drawn from B through the centre D is produced to I, which represents the place of the mean sun. Line LHK is parallel to BDI; point L indicates the mean apogee of commutation, K the mean perigee of commutation. Therefore, as the earth moves around D, line LHK will move at the same rate as line BDI--the mean perigee and apogee of commutation thus change constantly.

A line drawn from the earth (B) through the centre of the comet's orbit (H) is produced to N. N represents the apparent apogee of the comet's orbit while M (where the line crosses the deferent) represents the apparent perigee of the orbit. The motion of the comet about the centre H is not a simple circular motion along ELG but is also carried back and forth on diameter PQ of a small circle of libration PRQT (centre at O) which is represented in the diagram by an oval to indicate it is not in the plane of the deferent, but inclined 90° to it. While PQ is actually a curved segment of the circumference of ELG, the circle is small enough to consider PQ a straight line.

The libration motion is restored twice in one synodic period of the comet. At conjunction and opposition with the earth, the comet is at O (when lines HO and LHK coincide); when angle OHK is 45°, the comet is at Q; when angle OHK is 90°, the comet is at T, and so forth.

The mean commutation of the orbit is 1° 27' 17" per day, over twice as fast as Venus. The deferent is at a distance of 0.842 from the sun (the Astronomical Unit being 1.000); the radius of the circle of libration (measured as 7° 15') is, in the same terms, 0.020, a little less than the eccentricity of the orbit. Since angle BHK = angle DBH

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(the equation of Venus) is known, the other elements of the orbit can be found by reducing the values for Venus in the Prutenic Tables to the inclination of the comet's orbit (28° 58' compared with Copernicus' value for the inclination of Venus, 2° 30').

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_____. 344. Maestlin an Johann Weidner, 23 July 1586.

_____. 384. Maestlin an Johann Weidner, 21 February 1587.

_____. 445. Maestlin an Johann Weidner, 28 October 1587.

_____. 459. Maestlin an Johann Weidner, 5 January 1588.

_____. 462. Maestlin an Johann Weidner, 21 January 1588.

_____. 515. Maestlin an Johann Weidner, 19 November 1588.

_____. 579. Maestlin an Johann Weidner, 20 March 1590.

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UT. MS. Mi XII 27[b]. Maestlin an Johann Faulhaber, 18 January 1619.

ÖNB. MS. Cod. Vindob. 10561 6ff. Excerpta e Christophori Clavii apologia pro castigatione calendarii et ad ea responsio forte Moestlini in primis lineis.

ÖNB. MS. Cod. Vindob. 10837. fol. 1r-90r. Astronomicae observationes vicennales et eo amplius ab a. 1572 usque ad a. 1596 e schedes Wilhelmi Schickardi in unum congestae volumen.

ÖNB. MS. Cod. Vindob. 10913, fol. 34r-40v. Emendatio sphalmatum typographicorum in opere Palatino quodam geometrico et in magno canone Rhetici, nec non demonstratio, canonem tangentium et secantium in eodem magno canone Rhetici juxta finem quadrantis minus exactum esse.

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HAB. MS. Cod. Guelf. 15.3 Aug. 2°. Liber Epistolae.

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HAB. MS. Cod. Guelf. 84.3 Aug. 4°. Synopsis Chronologiae Sacrae Michaelis Maestlini Quondam Mathematici Tubingẽsis Celeberrimj. Cum harmonia vitae Jesu Christi.

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Alterum Examen Novi Pontificalis Gregoriani Kalendarii, quo ex

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ipsis fontibus demonstratur, quod novum kalendarium omnibus suis partibus, quibus quam rectissime reformatum vel est, vel esse putatur, multis modis mendosum & in ipsis fundamentis vitiosum sit. Tübingen: Georg Gruppenbach, 1586. [BM 9006.ccc.23]

Außführlicher und Gründtlicher Bericht von der allgemainen und nunmehr bey sechßehen hundert Jaren von dem ersten Keyser Julio biß auff leßige unsere Zeit im ganzen h. Römischen Reich gebrauchter Jarrechnung oder Kalender in was Gestalt er anfänglich gweßt und was durch länge der Zeit für Irthumb dareyn seyen eyngeschlichen. Item ob und wie er widerumb ohn mercklicher verkürtzung zu verbesseren were. Sambt erklärung der newen Reformation welche jetziger Bapst in Rom Gregorius XIII in demselben Kalender hat angestellet und an vilen Orten eyngeführet und was darvon zuhalten seye. Heidelberg: Jacob Müller, 1583. [NYPL]

Another copy in: Notwendige und gründtlich Bedenckhen von dem allgemeinen uhralten und nunmehr bey sechsehen hundert Jaren gebrauchten Römischen Kalender wie und ob etliche Irrthumb hiezwischen in demselbigen eyngeschlichen seyen. Item ob und wie zu corrigieren oder zu verbessern weren. Heidelberg: J. Spies, 1584. [BM 8560 c. 20 (3)]

Consideratio & Observatio Cometae Aetherei Astronomica, Qui Anno MDLXXX. mensibus Octobri, Novembri, et Decembri, in alto Aethere apparuit. Item, Descriptio terribilium aliquot & portensorum Chasmatum, quae his annis MDLXXX. & MDLXXXI. conspecta sunt. Heidelberg: J. Mylius, 1581. [BM 532.c.63]

Defensio Alterius Sui Examinis, Quo Ex Ipsis Fundamentis Demonstraverat, Quod Gregorianum Novum Kalendarium omnibus suis partibus, quibus quam rectissime reformatum vel esse debebat, vel esse putatur totum sit vitiosum. Adversus eiusdam Antonii Possevini Jesuitae ineptissimas elusiones, quibus ipse dum Examen illud extenuat & calumniis carpit, non solum imperitiam & vanitatem suam prodit, verum etiam (licet invitus & non cogitans) Novam Gregorianam Kalendarii emendationem magis confundit, & funditus everit. Tübingen: Georg Gruppenbach, 1588. [BM 531.g.8 (4)]

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Epitome Astronomiae, Qua Brevi Explicatione Omnia, Tam Ad Sphaericam quàm theoricam eius partem pertinentia, ex ipsius scientiae fontibus deducta, perspicuè per M. Michaelem Maestlinum Goeppingensem, Matheseos in Academia Tubingensi Professorem. Iam nunc ab ipso Autore diligenter recognita. Tübingen: Georg Gruppenbach, 1588. [BM V 20913]

Another copy: Tübingen: Gruppenbach, 1597. [BM 531.f.15]

Another copy: Tübingen: Gruppenbach, 1610. [BM 531.f.15]

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